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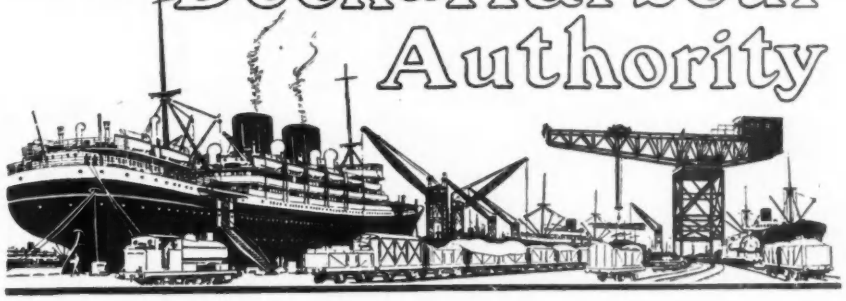

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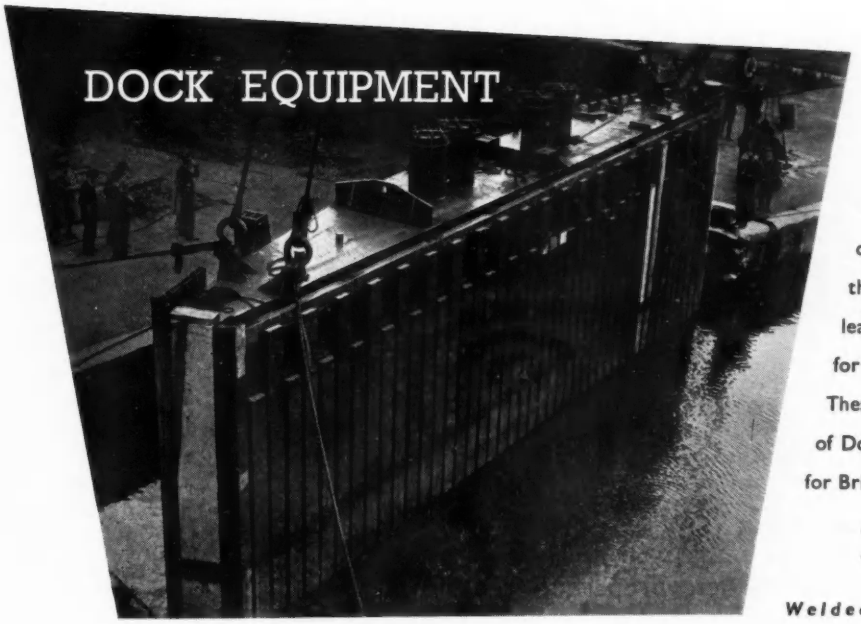

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Editorial Comments

United States Study of Ship Turn-Round.

The quick turn-round of ships is never a hackneyed subject. There are always new approaches to it, not only through the channels of handling equipment and methods but also through those of premises design, ship construction and even goods packaging.

The subject has recently been studied from a new angle by the National Research Council, Washington, U.S.A. The technique adopted was to examine, in separate "segments" (as the report calls them), the handling of a typical, complete ship-load of general cargo exported from the United States to Germany. The study, which covered the actual handling and movement of every consignment from the time it left the shipper's premises in the country of origin until it was delivered from port premises in the country of destination, aimed at establishing which segments of the whole operation offered the most fruitful fields for improvement, with the object of reducing the turn-round time of ships.

Data collected was collated in seven separate segments (1) the movement of the cargo to the loading port (New York), (2) the receipt into port premises (Pier 2, Brooklyn Army Base), (3) loading into the ship (the ss. "Warrior"), (4) the voyage, (5) discharge (at Kaiser Hafen III, Bremerhaven), (6) receipt in quay premises (Shed B) and (7) delivery from those premises.

The results of this initial study have been published by the Council under the title "The s.s. 'Warrior'". A review of this publication appears on page 49 of this issue and there is no doubt that the results of the investigation will be of interest and use to many organisations in and connected with the port industry.

Criticism of cargo handling methods and the speed of ship turn-round is always abundant. It is, however, so often made from a particular angle and thus fails to take into account all important factors. Seldom, indeed, are the critics so little personally interested that they can guarantee to be completely unbiassed. The body making the investigation under discussion appears to have no axe to grind. Their deductions and conclusions are, therefore, all the more likely to be valuable.

Recent Damage to the Genoa Breakwater.

The exceptional storm which destroyed a total of over 900 metres of the main breakwater at Genoa in February of this year is the subject of an article on another page by the Director of the Port of Catania, Dr. Agatino D'Arrigo. The principal feature of the disaster was the occurrence in 20 metres depth of heavy breaking seas, which expended their full destructive force on a vertical wall breakwater which was designed primarily for wave reflection.

The author instances similar occurrences at Catania and Algiers, while at the same time drawing attention to a hydrological feature which may exist in common to all three ports. This is the existence of submarine fresh water springs and prolongations of river beds on to the littoral floor, which in these instances are blamed for causing interference to the orbital motion of wave particles in such a way as to cause them to break. The author concludes by stating that it is necessary to have a complete knowledge of all the conditions, as well as experience in construction, in order to build safely at Mediterranean ports.

The effect on waves of discontinuities in the water is dealt with also in the articles on Pneumatic Breakwaters, to which reference is made below. It has been shown that both artificially and in Nature such discontinuities are able effectively to reflect waves, and to prevent their further progress. It would appear, therefore, that if Dr. Arrigo's thesis is correct, the peculiar conditions at Genoa, composed of both vertical and horizontal discontinuities, had the unfortunate result of causing the waves to break at the worst possible place, i.e. directly on to the stone breakwater.

German Research into Pneumatic Breakwaters.

A condensation of a report published in March of this year by the Franzius Institute, Hanover, appears in this issue. Articles on this subject have also appeared in our issues of May, 1952, and December, 1952.

The German conclusion is that Pneumatic Breakwaters are feasible and economic, and can be a useful substitute for conventional sea defences in situations where such defences are ruled out, either by reason of cost or because they would be a hindrance to shipping. It is also concluded that model tests cannot provide the data from which to construct full scale installations, and that the air requirements at full scale are 500 to 750 times less than those indicated by models.

As to the interpretation of results, informed opinion in this country does not altogether agree with certain hypotheses which have been advanced by the Franzius Institute.

Following the condensation of the German report is a review of this work, together with an interpretation which will be found to supply a common denominator to the action of the Pneumatic Breakwater and to those known instances of wave reduction or reflection which occur in Nature.

It is thought that this re-appraisal of the Pneumatic Breakwater will be of interest from the standpoint both of navigation and of harbour works requiring protection during their construction.

Suggested Integration of South Wales Ports.

At a recent meeting in Cardiff of the Joint Ports Committee of the Industrial Association of Wales and Monmouthshire, it was suggested that all concerned with shipping activities should study the possibility and advantages of developing the South Wales ports as an integrated unit, having due regard to the particular interests which each could best serve and handle.

Provided that unanimity is reached on the lines along which such a plan might be developed, the committee is confident that the British Transport Commission would be prepared to give full and careful consideration to reasonable recommendations. These would probably include a proposal that the example of other nationalised industries should be followed in devising a long-term plan and allocation of appropriate funds for improving and adjusting the existing facilities so as to render each port capable of dealing with a greater volume of traffic as well as providing accommodation and equipment for carrying out repair work on the larger types of cargo vessels.

A sub-committee is to examine the present scope of facilities at each port and will make recommendations in relation to the known and anticipated needs of the local industries and trades which they primarily serve.

It was reported that the B.T.C. had set up a committee representative of railway and dock managements on the subject of rail charges to South Wales ports and that exploratory discussions were already proceeding. On the subject of an adjustment in the division of dock charges between shippers and ship owners, the

Editorial Comments—continued

Minister for Welsh Affairs had intimated that owners were willing to discuss this question and he was arranging to bring the respective interests together for this purpose.

The Joint Ports Committee expressed the view that this situation represented a highly satisfactory point of progress in the endeavours of the Association to bring about equality of treatment for South Wales ports.

Reducing Oil Pollution.

The pollution of the sea by oil is a subject which has received frequent attention in this Journal, and any means which may be adopted to mitigate the nuisance is to be welcomed. The following report of a novel method of dealing with large quantities of oil discharged into the sea is therefore of interest.

According to the "Hamburger Anzeiger," a German engineer, Otto Schröder, is to patent an invention which he claims will be an appreciable help in combatting oil pollution in coastal waters. His invention was prompted by the case of the motor tanker "Gerd Mœrsk" which went ashore at the mouth of the Elbe at the beginning of the year. The weather was so bad that craft could not lie alongside to take off her cargo and 5,000 tons of oil had to be jettisoned before she could be refloated.

The invention consists of an impregnated sailcloth "lighter" which will fold up into a space of about 120 cu. ft. A pipeline from this can be floated to a stranded ship and coupled to its own pumps for discharge. The capacity is claimed to be up to 100 tons for either petrol or heavy oil. When full the pipeline can be sealed off and the "lighter" towed away.

As the device can be folded and carried on a ship's deck it would appear that a wider adaptation could be made of the idea, as it would be possible to pump residues of oil cargo into the lighter for disposal ashore instead of into the sea as is usually done.

Opening of Port of Kandla, India.

The Port of Kandla was officially opened to international maritime traffic in April last. This project, which has been completed in a little over three years, has provided the western coast of India with a second major gateway, and it is expected that the port will initially handle a traffic of one million tons a year, one half of which will be oil imports.

Serving a vast hinterland of eight States covering an area of 250,000 square miles, with a population of 60 million, Kandla has been built to replace the port of Karachi which was lost to India on the partition of the country, and is now one of the major ports of Pakistan.

The construction of the new port at Kandla will greatly assist in relieving the congestion at Bombay. It should also pave the way for the industrial development of Kutch and the surrounding area, which has rich deposits of limestone, silica, gypsum and bauxite. The narrow-gauge railway linking Kandla with Bhuj has been converted into a metre-gauge line, which will facilitate communication with the port.

Indian Port Delays.

In view of the interminable delays to shipping which are being experienced at all Indian ports, the developments at Kandla are to be welcomed as a step in the right direction. According to statements in the press, the congestion of shipping in India has become so serious that shippers in Great Britain, the United States and other countries have announced their intention of imposing a 25 to 30 per cent. freight surcharge on the majority of cargoes being loaded or unloaded in India.

Speaking at the recent annual meeting of the Oriental Steam Navigation Company, the chairman, Sir William Currie, said: "Our ships have suffered grievous delays, particularly at Calcutta and Bombay, and conditions at these ports have become progressively worse since the end of the year. Port delays are one of the shipowner's unsolved problems to-day. It is wrong that, despite all the expensive mechanical devices of the present age, ships are taking much longer to turn round in most ports than they did before the war. The effect of these delays is that the trade to India now requires about 25 per cent. more tonnage to maintain a given frequency of sailings than before the war. The greatly increased cost that this involves must necessarily be reflected in the rates of freight which are charged." This statement puts the position plainly and unless conditions improve some drastic remedy will have to be found.

In view of the threatened surcharge, the Indian Government has conducted an urgent enquiry into the dock labour position and claims to have effected some improvement. It also has requested the shipping lines concerned to wait until July 1 before implementing the proposed increased rates.

Topical Notes

Erosion and Silting Research in West Australia.

The problems of silting at Bunbury harbour and of beach erosion at Cottesloe are being investigated at Perth University, Western Australia. The investigations are being carried out under the supervision of Professor K. L. Cooper, head of the university's engineering department.

A concrete model of the breakwater area in the Bunbury harbour has been built in the Engineering School grounds. The size of the model is 100-ft. by 60-ft., with a depth of water of 10-in. An electric machine with a 40-ft. oscillating blade, producing model waves of one to two inches high, will be used to simulate the waves and their movement in the harbour. Practical work with the model follows a year's study of weather data, which has enabled the direction and size of waves to be calculated. It is anticipated that the Bunbury harbour enquiry will be completed in about six months.

Designs for a model of Cottesloe beach have been prepared and it is expected that experiments will be started shortly. Finance for this investigation, which will embody the study of the effect of groynes in combating erosion, will be met entirely by the Public Works Department of Australia. The cost of the Bunbury harbour study was met initially by a university research grant, supplemented by finance and equipment from the Public Works Department.

Dredging at Newcastle, N.S.W.

Ever since the port of Newcastle was opened the entrance to the harbour has been a hazard for shipping. In the past hundred years over a million cubic yards of rock have been removed to make the channel progressively deeper, and to provide for the ever-increasing draught of ships using the port. The present depth over the bar restricts traffic to ships of not more than 18,000 tons.

A special effort is now being made to increase the depth over the bar to 32 feet which will provide the necessary clearance for the biggest tanker and freighters trading in Australian waters. For this purpose the most powerful rock-breaker in Australia has recently been built by the New South Wales Public Works Department. Named the "T. J. Paul" the rock breaker has a deck space of 100 by 30 feet. It is not self-propelled, but is daily towed to and from the job, where it is positioned by six anchor chains converging on a six-drum winch amidships.

The "needle" weighs fifteen tons and is 27 feet long; the height of its drop varies from 9 to 14 feet. An underwater cylinder 24 feet long guides the drop and steadies the "needle" after impact. The depth of penetration by each blow is gauged from measurements on the 1¼ inch non-spin hoisting rope. The number of strikes per day varies from 100 to 550.

The "T. J. Paul" commenced work just over a year ago, and it is estimated that about 250,000 cubic yards of rock will have to be smashed and removed to give the required depth to the entrance channel. The cost of the vessel which was constructed at the State Dockyards, Newcastle, totals £92,000.

Discharge of Rubber Latex in Bulk.

A new plant for the discharge of rubber latex imported in bulk has recently been installed and brought into use at Tilbury.

By arrangement with the Port of London Authority, Messrs. Wm. Symington & Son, Ltd., have built an installation capable of storing large quantities of latex. Vessels carrying the latex cargoes berth at the Tilbury Cargo Jetty and the latex is pumped from tanks on board to the storage tanks in the docks. Delivery from the storage tanks ashore is effected by pumping into road tank vehicles. This is a new trade for the Port of London.

The Port of Hamburg

A Review of New Construction

by R. R. MINIKIN

(Continued from page 8)

Quay Walls.

Of the total length of 66 kilometres (40 miles) of quay walls that were in service in 1939, 36,000 m. for sea-going vessels and 30,000 m. for river and inland waterway craft, almost 15 per cent. were destroyed during hostilities, but today almost all are now repaired. In the last three years, work on the quays has progressed steadily and many of the old quays have also received attention. Considering the amount of other damage, it is remarkable that the quay walls escaped with relatively minor destruction, particularly in view of the fact that many of the walls were built on the old Hamburg design of massive masonry supported on a timber grid, at or just below low water, which in its turn was carried on natural timber piles, most of them raked inwards. The back fill was held by timber sheeting piles driven vertically at the back of the wall. Even in the reconstruction of some of the damaged walls, the old walls' remains have been in part left in place and incorporated in the stability of the new.

An example of this is the repair of the Augusta Victoria quay in the Kaiser Wilhelm dock (Fig. 11). This section shows that the engineers had every confidence in the durability and capacity of the old work, for they have used it as the central support for the new work of reinforced concrete. To the waterside the quay wall is extended outwards approximately 2.00 m. by an R.C. block supported on steel sheet piles, Larssen V, overlapping and keying into the old masonry. To the landside a R.C. apron or platform extends landwards for about 6.00 m. from the back face of the old wall and is supported on a group of 13½-ins. square R.C. piles.

This platform not only serves to relieve the earth pressure on the retaining sheeting, but also carries the concrete wall supporting the hinder rail of the portal crane. The rail gauge of the crane is 6.00 m. (19.6-ft.) for one wagon track. It is obvious that the steel sheet piling is a direct load bearing member and is not subject to any appreciable earth pressure, unless the dock bed is dredged deeper later.

Another example of this type of resourceful construction to obtain an extra width of quay to accommodate two wagon tracks and one portal crane was carried out at Versmann's quay (Fig. 12). Here the old wall was only partly utilised to contain the back fill and a portion of a (doubtful) three point loading, since the platform slab is continuous from the front of the quay face to the raked three pile group at the rear, supporting the hinder rail of the crane directly. There is no actual keying into the old wall.

An interesting and unusual form of wall repair was effected on the Schamer quay in the Oder Dock (Fig. 13 and Fig. 19). The old wall face was advanced dockwards by a little over one metre only to accommodate one rail of a half-portal crane spanning two rail tracks and the loading apron of Shed No. 80. The addition was achieved by a reinforced concrete cornice checked into the old masonry with spaced buttresses to the rear and supported at the front edge on Larssen V steel sheet piles. The shed is of timber construction resting on old foundation pedestals supported on piles, and to adequately support the landside crane rail R.C. columns are carried up from the waterside row of the original pedestals. To achieve lateral stability of the latter, raked reinforced concrete struts are rooted into the columns at shed floor level, connecting them to a R.C. rib cast on the rear step of the old wall: this in its turn is connected to raked steel piles driven at the steep slope of 45 degrees with the vertical. The toes of these piles have wings or ribs welded to them as shown. As a point of interest, one recalls that in 1927 the Columbus quay at Bremen was recon-

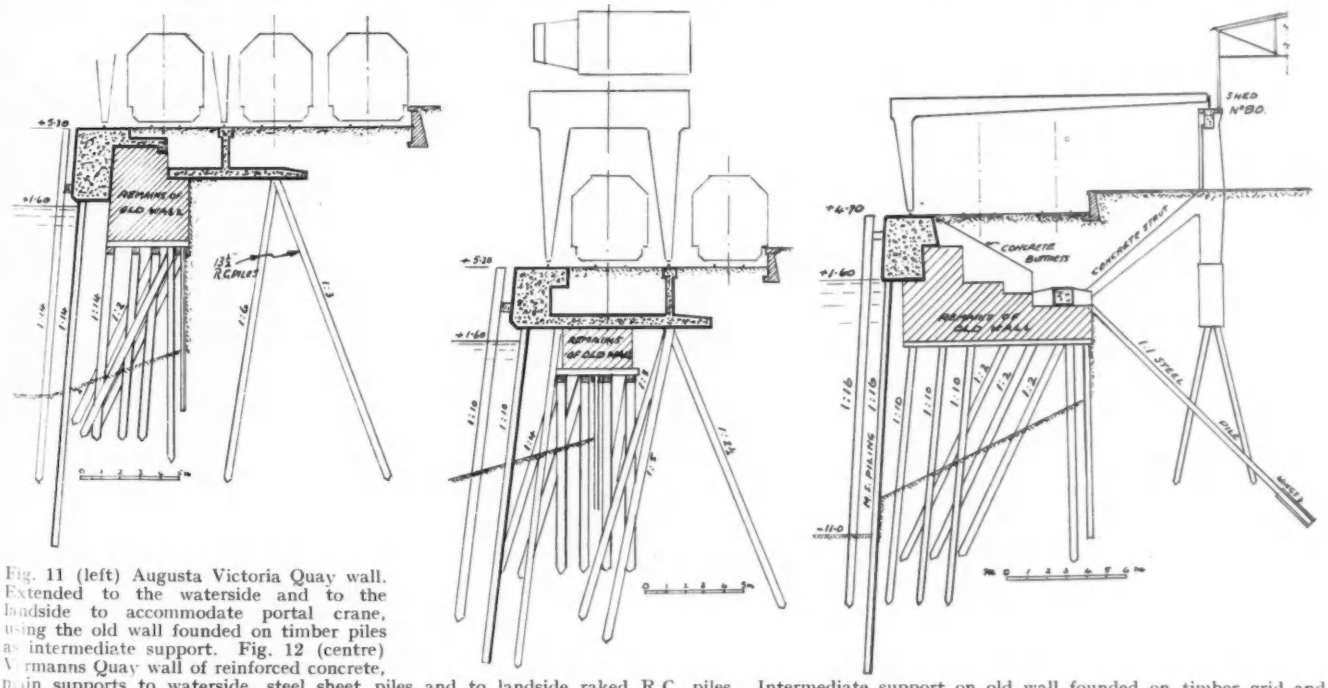


Fig. 11 (left) Augusta Victoria Quay wall. Extended to the waterside and to the landside to accommodate portal crane, using the old wall founded on timber piles as intermediate support. Fig. 12 (centre) Versmanns Quay wall of reinforced concrete, main supports to waterside, steel sheet piles and to landside raked R.C. piles. Intermediate support on old wall founded on timber grid and timber piles. Fig. 13 (right) Schamer Quay Wall. At the head of the Oder dock. A remarkable utilisation of remains of the substantial old wall of masonry on timber piles in deep water. The steel anchor pile to the rear is driven at inclination of 45 degrees with the vertical and secured at the head in a reinforced concrete rib which also holds the bottom end of the R.C. strut to secure the crane supporting leg of the Shed No. 80 of timber construction.

The Port of Hamburg—continued

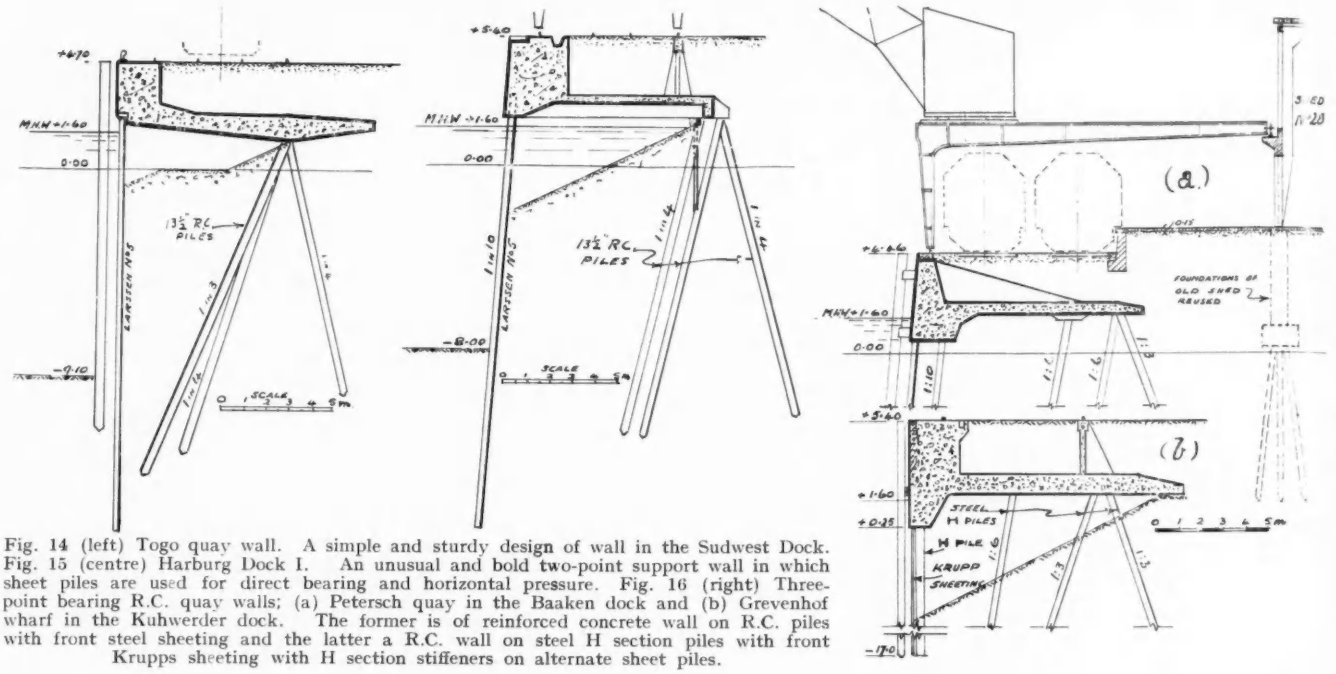


Fig. 14 (left) Togo quay wall. A simple and sturdy design of wall in the Sudwest Dock. Fig. 15 (centre) Harburg Dock I. An unusual and bold two-point support wall in which sheet piles are used for direct bearing and horizontal pressure. Fig. 16 (right) Three-point bearing R.C. quay walls; (a) Petersch quay in the Baaken dock and (b) Grevenhof wharf in the Kuhwerder dock. The former is of reinforced concrete wall on R.C. piles with front steel sheeting and the latter a R.C. wall on steel H section piles with front Krupps sheeting with H section stiffeners on alternate sheet piles.

ditioned on a similar principle, with the difference that sand fill was placed behind the steel sheeting piles, and this was tied back into an anchorage behind the old wall by deflected tie bars, using the latter as a saddle. In the considered example, the steel sheet piles at the quay wall are subjected to direct vertical loading only: the retained backfill is inappreciable.

New Design.

Just before the World War II, the first considerable change in Hamburger (II)[11] practice in quay design was initiated. The heavy block masonry walls supported on large numbers of timber piles gave place to light types of L shaped reinforced concrete sections supported on steel sheet piles and reinforced concrete piles to the rear economically placed in the points of maximum vertical loading. Variations of the original Danish two point support type were dependent on the local quay loading and the strata variation of the sub-foundations and were suitably adapted for three or four point support to the relieving platform, with wider spacings of the hinder piles in effective patterns to achieve maximum economy. The more recent tendency is to relieve the face steel sheeting from the horizontal thrust of the backfill to the greatest possible extent to avoid the use of tie-bars, the compensation being provided by the backward prolongation of the platform or the not so effective expedient of an intermediate short pile sheeting to the rear of the wall.

The more general nature of the Hamburg strata is a top layer of old fill from ancient buildings overlying successive layers, in varying orders and thicknesses of strata, of clay, sand and gravel. There is on the average a deep bed of coarse large grained sand at a depth of 10-13 metres below the surface. It is into this bed that most of the piles reach set: in the river bed it lies at about 6 m. below bed level. Frequently pockets of indurated mud are encountered in the sand bed.

About 1937 the wall of the Togo quay in the Sudwest dock was reconstructed. The design comprised a horizontal platform of reinforced concrete, with the base just above mean high water level (+ 1.60 m.), in which was rooted the vertical dockside wall (Fig. 14), forming an L shaped section. This platform had a two point support: at the dock face direct bearing on a steel sheet pile wall (Larssen V) and to the landside on a pile group placed about five-eighths the width of the platform from the sheeting wall. The overhang thus formed an additional width to the relieving platform and as a cantilever provided a partial balance to the vertical loading on the front wall sheeting. It is also to be noted that the backfill was sloped down from the underside of the platform near the pile apex to a level below datum, thus diminishing the horizontal stresses on the wall. Another feature is of interest insomuch that the R.C. pile groups of three were spaced at 5-ft. between the centre line of each group. Taking the innermost pile axis as the centre line, the 3 : 1 raked pile axis lies parallel to one side and the 4 : 1 raked pile parallel with both to the other side. This arrangement widened the straddling of the ground bearing distribution in the large grained sand at the toes.

The thickening up of the platform slab immediately above the piles provided for reverse bending moment and shear stresses. The R.C. piles were 13½-in. square. Following the usual Hamburg practice, the quay wall was faced with basalt with a coping of dressed granite.

Within the last few years, a bolder and simpler design of the two point support for quay walls has been evolved by " Strom und Hafenbau " and constructed at Sea Dock No. 1 at Harburg (Fig 15). Again the level of the underside of platform was fixed at about 14-in. above M.H.W. This now appears to be the present Hamburg practice for all new work not involving the use of timber grids or piles, although at Cuxhaven the new L shaped R.C. Fish quay rests on Krupp steel (K.S. 2) piles at mean tide level (±0.00). In the present example the thin platform slab is supported on transverse beams spanning from the sheeting wall to the pile groups, where they are widened out to form pile caps housing the heads of groups of five R.C. piles. The beams and the pile groups are spaced 4.00 m. apart. Each pile is 13½-in. square, and all are raked at 3.5 : 1 with the vertical, all axes being parallel one with the other and lying in planes normal to the quay face. In some groups four piles are to one side of the vertical towards the quay wall and one centrally driven pile lies on the opposing rake on the landside. Separating these groups, the alternate clusters have a different pattern: three piles centrally placed are on the waterside of the vertical and two piles are on the opposing rake to the landside and the outside of each group.

The landside rail of the portal crane is carried by a stout R.C. beam resting on pedestals at 4.00 m. centres. The shoes of all piles rest in a deep layer of coarse sand and gravel. It is noted that the steel sheeting wall is battered at 10 : 1 and that the backfill lies at the natural slope meeting the back of the sheeting (at – 1.30 m.) below mean low water level, thus relieving the wall of considerable horizontal pressure.

The Port of Hamburg—continued

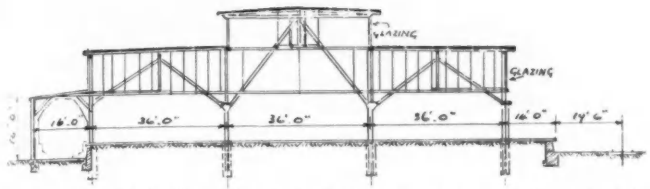


Fig. 17. Shed No. 84 of timber construction of distinct old Hamburg pattern.

The new portion of the quay wall (Fig. 16) fronting shed No. 28, on the Petersch quay in Baaken dock, is a reinforced concrete L shaped wall with three point support in which all piling is inclined to the vertical. The platform extending landwards 11.00 m. from the quay face, the opposing raked piles being placed well to the rear edge.

Quayside Sheds.

The greatest damage to the docks of Hamburg during hostilities concerned the immediate port facilities, sheds, warehouses, cranes and equipment. In 1939 there were no less than 99 closed sheds, having a total usable floor area of over 700,000 square metres and warehouses equipped for special goods storage of over 800,000 sq. m. floor space. In 1946 the port was left with only 40 per cent. of sheds and about 30 per cent. of warehouses serviceable under difficulties. Since that time the recovery in the period 1946-1949 was slow; the quays' surfaces were a shambles, the direction neither had money, material nor freedom to embark upon rehabilitation outside of the military requirements of the occupying forces. However, the traffic necessary for the allied armies did provide a means for reconstruction, and since 1949 there has been a progressive increase of new construction, repair and re-design. At the present time, there are 58 sheds in full working order having a floor area of 428,000 sq. m., including 50,000 sq. m. of thermally controlled fruit sheds and 30,000 sq. m. of up-to-date fish markets and allied industries. The available warehouse area is now 450,000 sq. m., including cold storage of 40,000 sq. m. There are also grain silos with a capacity of 270,000 tons. These last two items, due to war necessity, were always kept above peace-time requirements throughout the duration.

Besides the above, the tank storage exceeds 1,000,000 cubic metres, which is 33 per cent. below pre-war.

The old quayside shed designs were typical of the port. They were mostly of timber, imported from South America, the Far East and Sweden. They were wide (33-40 m.), long (300-350 m.) and squat, having about 5 m. clear internal headroom and 9.00 m. to the eaves. They had flat roofs (sloped about 1 in 40) and central lanterns with side glazing. The side walls had sliding doors, giving about 40 per cent. opening for a height of about 4.00 m.; the upper parts of the walls were glazed for almost the whole length. They were, in spite of this, not unpleasing in appearance. Near the middle of the length there was a taller administration building and offices for shippers, etc., behind which part of the shed was partitioned off for shed servicing gear and mobile equipment. To reduce the fire risk, brick walls with fire doors separated the length into convenient compartments. Quite a large number of the older sheds had narrow aprons and poor approach roadways for lorry traffic on the landside.

The floors of the sheds were almost invariably paved with hard wood sleepers resting directly on sand. This Hamburg practice was found convenient and locally economically satisfactory, since the periodical levelling up required when settlement occurred could

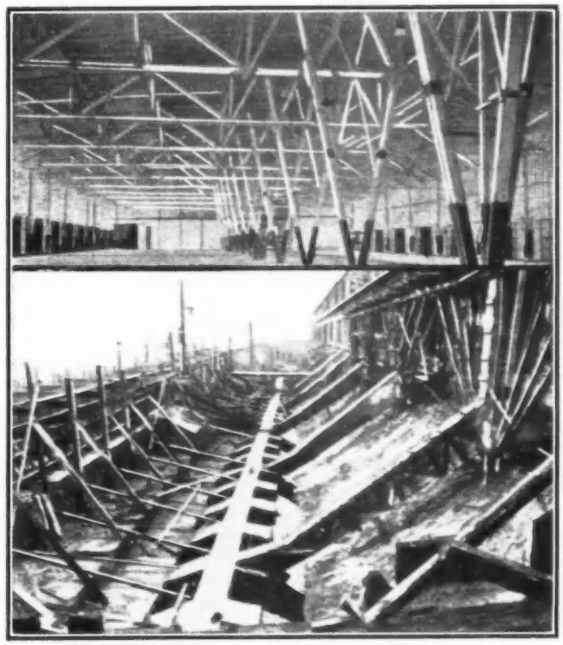


Fig. 19. Upper, inside view of Shed No. 57, note longitudinal bracing strut in right foreground. Lower view of top of quay wall masonry and diagonal struts to foundations of Shed No. 80 (Fig. 13).

be carried out easily without interruption of use. Another point of importance was that the timber floor did not favour condensation, which might be deleterious to merchandise of delicate nature. This principle of flooring, unsecured in place, of comparatively light and easily handled units bedded on sand, has for so many years given efficient results in Hamburg that its use, with slight modifications, is now spreading into other countries.

Reinforced concrete slabs have been tried without success; the weight and unelastic nature of the material militated against its other advantages. A further defect was the condensation of moisture, necessitating the use of timber bearers to keep the stored goods from the floor. In Germany there has always been a great demand for timber construction and the craftsmanship has always been of a high order. The carpenters are particularly good on heavy constructional work and the designers proficient in economical layout. The latter quality is to be noted in the omission of redundant members commonly seen in the constructions of similar buildings in other lands. The success of timber construction mainly lies in the thoroughness of the workmanship and the placing of the joints and scarphs—in this the Hamburgers excel.

The "Strom und Hafenbau" department (the Port Engineer's office), when proceeding to invite tenders for new construction of

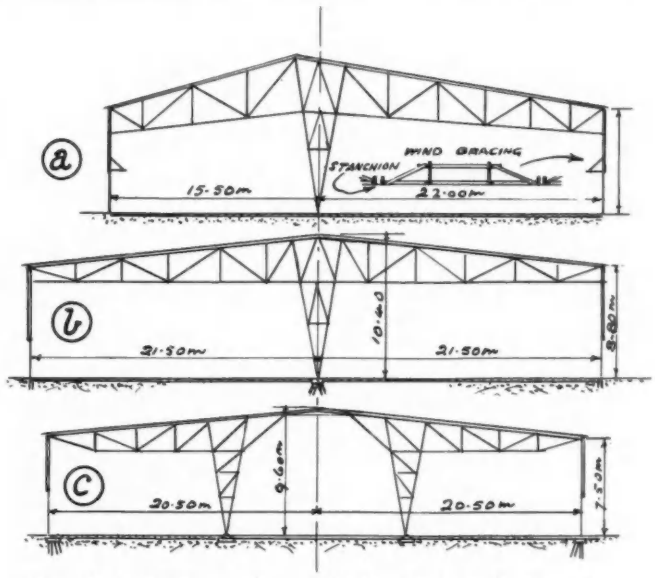


Fig. 18. Three types of recent timber shed construction (a) Shed No. 22, (b) Shed No. 57, and (c) Shed No. 58; (a) is on the Vermanns Quay and (b) and (c) on the Togo Quay.

The Port of Hamburg—continued

an expensixe nature, introduces a form of competition amongst the tenderers. This gives great opportunity to exploit economical and modern design, in layout and materials, of mutual advantage to the Administration and to the contractors. Tenders are invited for the Authority's design and/or for an alternative design to be submitted by the contractor for the same purpose. All are considered and

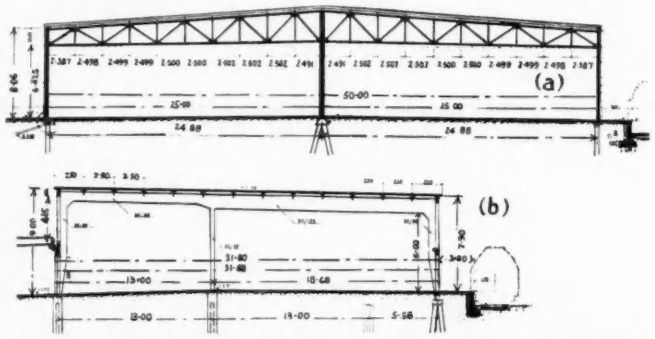


Fig 20 (a) Steel-framed Shed No. 74 on the Kronprinz Quay in Kaiser Wilhelm Dock ; (b) Reinforced concrete structure of Shed No. 28 on Petersch Quay in the Baaken Dock.

that which is favourable in price, layout, and materials is usually accepted. This does not always mean the lowest overall tender (price), but this is usually the case. As a result of this practice, the docksides of Hamburg are becoming more diversified in appearance, with the imposing facades of the new sheds, so different from those of several decades ago.

Timber Constructions.

On the Ross quay, in the Ross Dock, Shed No. 84 has the pre-war typical appearance although it is but newly built. The old shed which it replaces in part, for it was not entirely destroyed, was about 350 m. long and 33.0 m. wide. It has therefore been reconstructed more or less as originally designed (Fig. 17), as a low timber building with an almost flat roof with a glazed lantern occupying the central third of the width for the whole length. There are four longitudinal rows of mild steel stanchions on the old foundations supporting the timber trusses, of which the main members are disposed in much the same form as house roof rafters. The roof beams are supported on these and further strengthened by vertical studding. The height of the sliding doors is about 10-ft. and the height to the eaves 8.10 m. (26.5-ft.). In the shed the clearance from the floor to the truss horizontal tie is about 14-ft. It is obvious that the design is simple and that there is a good light in the shed; nevertheless there is almost 56 per cent. of the covered volume in the shed useless, excepting of course its aeration value. However, there is not a great deal of stacking in Hamburg sheds as a rule; the floor space is extensive (in this shed, 124,000 sq. ft.) and the despatch expeditious.

In the post-war reconstruction several new designs of timber sheds have appeared: the variation between them is not great, yet none as simple as the one described above. From the point of view of utilisable volume, however, the new designs are more economical. The common feature in all of them is the forked V form of the main internal stanchions (Fig. 18). They are raked transversely outwards from the base at an inclination of 1 : 6; each leg is formed of double timbers spaced 10 cm. apart. The scantlings are 14/16 x 22 cm. section with cross bracing of 2/10 x 16 cm. and 2/6 x 12 cm. The top and bottom members of the side trusses are about 2/10 x 16 cm. with 3, 2, or 1/10 x 16 in the diagonals, with verticals ranging 10 x 12/16 cm. section. These scantlings are about the average, for obviously they vary with form, load and span.

The vertical stanchions at the outer walls are usually double timbers spaced apart and are 2/16 x 25 cm. at about 9 to 10 m. centres. There are intermediate stanchions at third points from ground level to the main longitudinal ribands (18 x 18 cms.) forming the door lintels of 12 x 18 cm. each. From this level to the window lintels at the eaves, the scantling of these posts is decreased to 12 x 14 cm. The eaves lintel is 12 x 14 cms. The side walls' wind bracing (Fig. 18a) at door lintel level has tension members of 10 x 12/14 cm. with compression struts of 10 x 10 cm. The longitudinal truss bracings have top rails of 10 x 14/16 cm. and are spaced at each vertical strut of the main frame trusses (about 3.5 m. apart). The scantling of the diagonals is 10 x 12/14 cm.

Near the gable ends of the sheds and occasionally in the length, the longitudinal bracing is carried down to ground level by an extra leg to the V stanchions, or a trussed portal frame is inserted in the stanchion rank.

One of the latest sheds is No. 22 on the Vermanns quay, in the Baaken dock near the old city. This quay is about one and a half kilometres (4,820-ft.) long and is much used by coasters and heavy inland craft. The shed has a length of 400 m. and is L shaped in plan, the shorter length turning into the Magdeburg quay, where it is 42 m. wide. From this end to the east gable the width is reduced in 2.00 m. steps to 28 m. to conform in shape to the existing rail layout. Fig. 18a shows a diagrammatic cross section about mid-length, where the truss spans are of unequal length. The line diagrams of the main structural members of

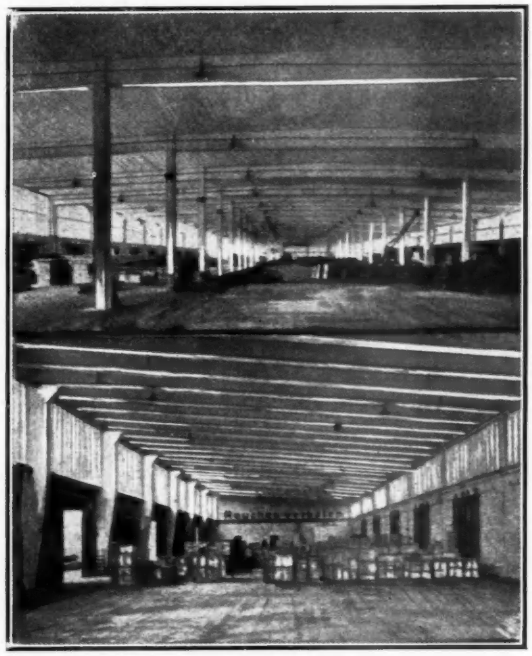


Fig. 21 (a) Flat arch construction, Shed 55, in reinforced concrete, span 9.00 m. between columns longitudinally, and 15.0, 19.0, 15.0 m. transversely. Width of shed 160-ft. ; (b) Flat roof beam and slab construction in single span reinforced concrete frame, Sheds Nos. 4 and 5.

sheds Nos. 57 and 58 on the Togo quay in the Sudwest dock are shown in Fig. 18b and c, and Fig. 19a respectively. The former follows the common or usual form of roof truss with central support, whereas the other shows economy and originality of design of truss work over the central bay and simple hinged support at the outer walls. A variation of this latter design was used for shed No. 80 on the Schamer Quay in the Oder Dock. It is 6.0 m. wider than No. 58 and the central span is 4.0 m. greater than the side spans. For this reason, and because of a quayside wall forming support for a semi-portal crane, a shallow truss was placed in the central span and the lower boom of the side trusses was extended to the wall stanchions (Figs. 13 and 19a). Shed No. 57 is thermo-controlled for the reception of fruit and is fitted out as described for sheds Nos. 34 and 37. These sheds have a pleasing appearance inside and outside, as the photograph (Fig. 19a) shows. One must add that it is distinctly impressive to see the nimble and workmanlike manner of erection of these timber structures: the side bays are first dealt with and closures made on the central bay.

The Port of Hamburg—continued

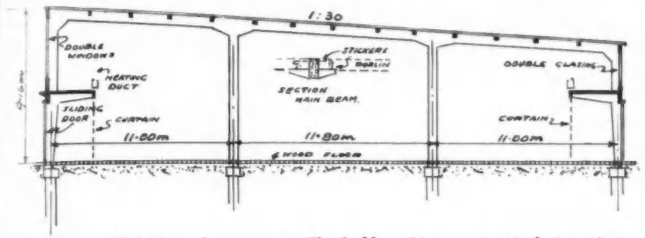


Fig. 22. Reinforced concrete Shed No. 34 constructed to store delicate fruits.

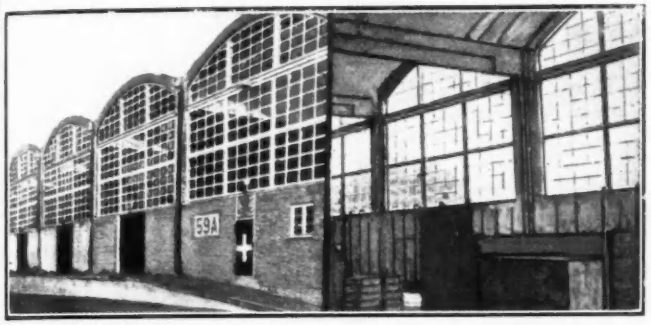
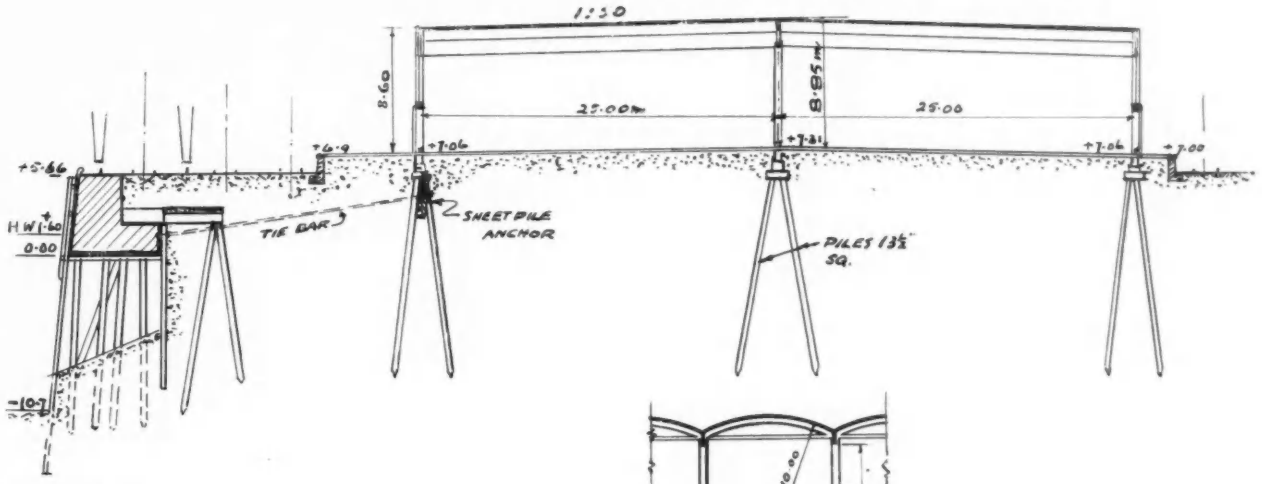


Fig. 23. Reinforced concrete barrel roof Shed No. 59 showing large extent of side glazing and the pleasing appearance inside.

tried out for the floor space instead of the customary wood sleepers, which were used only for trolley tracks. The author was given to understand that the shed staff preferred the old method. A light weight concrete was used for the pre-fabricated units of the roof covered with 2-in. thickness of cork and bitumen—which, when sprayed with liquid asphaltic composition, was covered with bitumenized sheeting.

Reinforced Concrete Construction.

The main change in the Hamburg quayside constructions is the greater use of reinforced concrete, and with its attendant design a more pleasing and certainly a more modern appearance. By that is meant that the new sheds have the impression upon the observer of functional efficiency and sturdy durability. One of the simplest of these new R.C. buildings is Shed No. 4 on the Sandthor Wharf near the City. It is a narrow structure (56-ft. wide) with a single span of simple robust design (Fig. 21b). The quayside legs are haunched and designed as articulated frames incorporating sturdy longitudinal beams and a cantilevered slab just above door lintels to carry the rail track of quayside semi-portal cranes. The land-side stanchions of the frame are simple columns connected longitudinally with R.C. continuous door lintels and eaves beams. Like most Hamburger buildings the foundation is of piles which, for the quayside legs, are opposing rake and vertical for the land-side columns. The frames and beams were cast in situ, but all other concrete, rafters, etc., were pre-cast. The roofing was of light-weight pumice concrete (Meurin type) slabs. The photograph shows that the shed is well lighted and that door openings are 40-50 per cent. of wall run. The floor is the customary timber



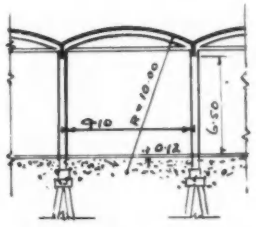


Fig. 24. Reinforced concrete barrel roof Shed No. 75 similar in main construction to Shed No. 59.

Steel Construction.

There are not many steel sheds in Hamburg for the reasons already given, and one of the more recent is Shed 74 on the Kronprinz Quay in the Kaiser Wilhelm dock. It is 50.0 m. wide and 400.0 m. long, with simple outside wall stanchions and a central row of inside stanchions with roof trusses of welded mild steel spanning 25.0 m. (82-ft.) (Fig. 20a). The wall stanchions are H. section and the centre stanchion of battened channels, with bases secured to sturdy concrete cap beams topping the piles. The longitudinal column spacing is 9.10 m. enclosing brick panels about 3.25 m. high, the rest of the wall height being occupied by double wired glazing to the eaves. The sliding door openings in the side walls are about 50 per cent. of the wall length. From the floor of shed to lowest member of truss is 6.20 m. (21-ft.). The roof slope is 1 in 16, steeper than usual, and floor slope from centre to side is 1 in 100.

Like all the other sheds the Administration building is in the middle of the length of shed, as is also the services depot. Brick bulkheads are constructed transversely at about 100 m. apart for fire security. They are provided with fire-proof doors and under the services depot there is a tunnel to allow access between shed divisions on each side. In this shed reinforced concrete slabs were sleeper type laid on sand. Most of the shed sliding doors are inside the building.

A somewhat larger shed is No. 28 on the Petersch quay in the Baaken dock in which the transverse R.C. frame is in two spans, 15.0 m. and 18.60 m., with sturdy wall columns and slender internal columns (Fig. 20) designed purely for direct vertical loading. The outer columns, as will be seen in illustration, are assumed to be pin-jointed at the base, one to the left supported on pedestals of old foundations (as are also the centre line of columns) and those to the right are on new piling outside of the old.

The Asia quay in the Segelschiff dock is fully equipped for the reception of fruit. There are four thermostatically controlled sheds, Nos. 34, 35, 36 and 37, each about 720-ft. long and 110-ft. wide. The most recently constructed is shed 34. All are of reinforced concrete construction with slight deviations of design; besides the outer legs of the frame there are two inner rows of columns dividing the total width into three almost equal spans (Fig. 22). Above the

The Port of Hamburg—continued

door lintel height a cantilevered R.C. balcony is built on the inside of the outer legs of the frames, extending for the whole length of the building. On the quayside legs, outside of the shed, a cantilevered platform to support the hind rail of the semi-portal quayside cranes is also built about the same level as the floor of the balcony. The balcony serves the double purpose of supporting the air heaters for the shed and to support the hanging curtains to avoid the entrance of cold air when the doors of the shed are opened. Expansion joints are placed in all longitudinal beams at about 100-ft. spacing. The high side of the shed faces the quay and the roof slopes back at a fall of 1 in 30. Cast in with the main roof members of the frame, short concrete spurs, as shown, at 2.50 m. spacing are provided to receive the ends of pre-cast concrete purlins. For this purpose reinforcing bar stickers are cast in the frame beam, and the spur brackets and the pre-cast purlin end steel bars are left projecting to mesh in with them. The remainder of the concrete is poured in situ after the envelopment by steel shuttering. The final roof covering is of light-weight concrete and cork composition covered with bitumenized felt as already described. All windows are double glazed, and in sum they occupy more than 40 per cent. of the wall area.

Shed No. 37 differs from 34 in having a railway siding running through the landside bay inside the building to load up the wagons under cover.

Barrel Roofs.

For single storey industrial buildings in Britain since the war, reinforced concrete shell or barrel roofs type has developed considerably. The interesting point is that one of the Hamburg post-war sheds, No. 59, which was severely damaged, was one of the early examples of this construction designed by the originators, Messrs. Dyckerhoff and Widmann[12]. The shed was on the Windhuk quay, at the head of the Sudwest dock, and has now been reconstructed; Fig. 23 shows inside and outside views of this building as it now stands. In the old design the side walls had only half the area of glazing of the present—it then comprised a rectangular window above the door lintol to the bottom of the chord tie of the arch: above this there was a segmental window between the arc of the roof and the tie. The present pleasing appearance inside and out is due to the large expanse of glazing above the door lintol level. Another innovation in this shed is the location of the Administration block (which usually occupies the central section over the full width of the shed) to the landside between the central columns and outer wall, thus leaving a clear run through on the shed floor level instead of the more customary tunnels as already described.

The radius of the arched roof is 10.0 m. (32.8-ft.) and the length of the arch tie, ends and centre, is 9.10 m., which is also the distance between the centre lines of columns supporting the springing beams. In shed 59 this tie is below the springing beam, whereas in shed 75 it is approximately the chord of the segment (see Figs. 23 and 24). The thickness of the shell is 3½-in. It will be noted that the arch slopes downwards to both sides from the centre line of building at an inclination of 1 in 50. The springing beam between columns is 1.20 m. deep and 9 to 10-in. wide. In shed 75 the wall segments are not glazed, but are filled in solid with reinforced concrete. On the centre line of building between columns the ridge arch is strengthened with a R.C. rib about 16-in. deep and 8-in. wide: the chord tie is about 8-in. square. There are expansion joints at every four bays, roughly 120-ft. Unusually, this shed floor is paved with concrete slabs about 40-in. square laid in bitumen.

There are other sheds, Nos. 55 and 56, of a flat arched form on the Afrika quay in the India dock and others, Nos. 71 and 72, on the Auguste Victoria quay in Kaiser Wilhelm dock. The roof tops are entirely plain, the former with double inclination from a ridge on the centre line and the latter two inclining in one direction only downwards from the quay side. The intrados is thinned down from the springing beams to centre of arch. Spans are similar to the above examples. Floors are of the usual Hamburg timber sleeper type. Lorry access to quay and land sides of Shed No. 71 has been carefully planned to give an unhindered run through on ramp and road without interference to lines of rail traffic.

[11] Wolfram Schenck—"Neure Ausfuhrungen von Seeschiffkaien", Hansa 38/39, 1952.

[12] Cement and Concrete Association brochure, "Concrete Shell and Barrel Roofs", intro. Bb 5, 2nd edition.

The Baltic and International Maritime Conference

Jubilee Meetings held in Copenhagen

The fiftieth anniversary of the Baltic and International Maritime Conference was celebrated in Copenhagen from 16th to 20th May, 1955, under the chairmanship of Mr. Ths. S. Falck, Jr., of Bergen, who has been President of the Conference for the past two years. At the meetings a number of topics were discussed, and the following is a summary of the main items of interest to readers of this Journal.

Presidential Address

In his presidential address Mr. Falck reviewed the work and progress of the organisation since its inaugural meeting on February 16, 1905. He pointed out that from an initial membership 50 years ago representing between 900,000 and one million tons gross, the Conference had grown steadily. Before the second World War, the membership amounted to about 11 million tons. In 1945—on account of the war—this had dropped to about 6½ million tons; from then it had steadily increased. When his term as president started two years ago it was 16 million tons. The total to-day was about 18½ million tons, comprising some 4,313 vessels. He thought that this increased tonnage could be taken as proof that more and more shipowners appreciated the benefits derived from membership. Besides the owners, there were two other categories of members—shipbrokers and club members. Altogether the members numbered about 1,400, domiciled in 35 different countries.

Exemplifying the way in which the organisation had impressed itself more and more on the shipping industry, Mr. Falck said if a name should be chosen to-day, fittingly to cover the interests and ramifications of the conference, it would be the International Maritime Conference, because to-day, while still devoting much attention to the European short-sea trades, especially the Baltic trade, the conference dealt with trades the world over. The word "Baltic" was a reminder of days past, when the work began. In his view the work of the conference should be of equally great importance to charterers, shippers, and receivers, as it was to owners. A well-organised trade would undoubtedly in the long run attract the best and most efficient tonnage and provide the cheapest market rates.

Mr. Falck then spoke on the vexed question of flag discrimination as being one of the serious problems affecting the shipping industry and, in particular, privately owned companies.

It did exist, to some extent in the past but in some of its present forms it might be regarded as a modern disease. Some of the new measures were so flagrantly in disaccord with accepted commercial practice that they could be unhesitatingly condemned. There was the juggling with import licences for the purpose of influencing the routing of goods. There was similar juggling with foreign exchange permits. Considerable reduction in charges was granted to goods shipped by vessels belonging to the national flag. Priority was given for the use of port facilities to vessels belonging to the national flag.

There was the serious tendency in certain countries of governments discriminating against foreign vessels. If all countries insisted upon carrying 50 per cent. of their own products shipowners would obviously be faced with a terrible waste of space

Baltic and International Maritime Conference—continued

as it would result in many vessels carrying cargo only in one direction and proceeding in ballast the other way.

The countries which for many years past had specialised in carrying cargoes on the high seas, and had done so very efficiently, on a fair commercial basis, obviously might suffer a lot.

The practices might prove to be a boomerang against the countries applying them, because in the long run they would stop the maritime countries from buying their products. Shipping, after all, was only a form of export.

Tariffs and Port Charges.

Dealing with the problem of tariffs, Mr. Falck pointed out that in practically all ports in the world, different systems applied by which tariffs were set up and charges levied. Taking the long view, the goal should be to get a uniform nomenclature and tariffs worked out after the same system, the port dues being charged on the N.R.T., and the use of quays and docks either being entirely free or paid for on the same basis in all ports. The competition between ports in the United States, as well as in Europe, had led to many curious tariffs and ways of charging dues to vessel for the use of berths.

In some Continental ports this had led to abuses. For instance, some port authorities in their tariffs stipulated that charges based on the weight of the cargo loaded or discharged—according to many charter-parties payable by the owners of the goods—were to be debited the vessels. Nevertheless, in addition, a charge was made against vessels on their N.R.T. as part of the quay dues. This was usually part of the policy of the port authorities to be able to explain to exporters and importers that the charges of the particular port on the goods were low, but in fact it might be claimed that instead the ports concerned just try to make shipowners pay. Actually it was the total cost to the ship and cargo which decided whether a port was cheap or not. In many cases it was most unsound to attempt to debit the ships with expenses which were of no concern to them, but rightly should be borne by the goods. All members should be on the alert and oppose any tendency to debit vessels with items which were not and should not be for their account.

Strikes and Port Congestion.

In a reference to strikes and discontent and to ship delays in port, the speaker continued:—

"Great strides have been made in the Western countries, in raising the social level of all classes of workers. Shorter hours have been conceded. Weekly guaranteed pay has been introduced. Holidays with pay have been agreed. Health insurance takes care of sick and ailing workers. Pension schemes, private and state subsidised, take care of the old. Welfare boards deal with the personal problems of workmen and special conciliation committees are found in a number of ports to iron out small grievances.

"Numerous ports during the last few years have been fitted out with the most modern equipment in existence for handling goods —fast working cranes, big grabs, speedy conveyor belts, fork-lift trucks and so forth—relieving dock labourers of much of the manual labour previously required.

"Nevertheless, in some ports, there appears to be more discontent, more complaints and certainly there are more strikes and delays, generally speaking, than we witnessed before all these improvements were put into effect.

"As we all know the cost of new vessels to-day is a very high one. What is the use of shipowners equipping their vessels with modern cargo handling gear at high expense, providing ever faster vessels to convey goods by sea when for some reason—frequently a trifling one—port labourers, dock labourers and stevedores do not put in an honest day's work, stop work, "go slow" or stage strikes, be they "official" or "unofficial."

"Admittedly, the exporters and importers suffer with the shipowners from the delays to vessels and goods, but in the end it is the community as a whole that suffers and it is the consumer who feels, if not the effect, then the after-effects, of any stoppages. Economic laws cannot be set aside and sooner or later the freight and the price of the goods affected will be increased.

"There is little doubt that some of the conflicts in ports—I am thinking of the strikes in the U.K. in 1954 and the labour trouble on the water front in New York—have been due to friction between rival labour unions and their leaders. Tremendous harm is being caused to the community and to the economy of the countries where these stoppages, strikes and delays occur. To improve still further the relations between the employers and the men working in the ports is really of the utmost importance."

The Iron Ore and Bulk Cargo Trade

The changing pattern of the world's iron ore trade was outlined in a paper entitled "The Principal Iron Ore Deposits and Movements of Iron Ore by Sea," by Mr. Sveno Brusewitz, of Stockholm.

As a starting point, the speaker gave figures showing the growth in steel production, which in 1937-38 was about 130/135 million tons per year. Production this year would exceed 240 million tons, which would mean very close to 100 per cent. more than the pre-war level. When it was considered that the iron ore of which most of the steel of the world was produced generally came from deposits having an iron content averaging about 50 per cent., they would get an idea of the quantities of iron ore involved.

Illustrating how the opening up of the new ore fields had influenced the shipping side, Mr. Brusewitz pointed out that when the smaller iron ore deposits in the U.S.A. did not suffice, there had been an immense reserve to be worked around the Great Lakes, especially the Mesabi range. The iron ore mined in this range had been up to the last few years with a few minor exceptions the only iron ore source for the growing United States steel industry. Shipping of iron ore in the United States thus has been a domestic affair on the Lakes and of no interest for international shipping. During the last war the industry had to dig into these deposits on a heavier scale than ever before and it had become necessary to look for other sources. At this juncture Brazil, Liberia, Venezuela, Labrador and Peru entered the picture. Both the Venezuelan deposits, at a distance of about 4,000 kilometres from the steel works in the United States, and the Labrador ores at half that distance were low-phosphorus ores and consequently well adapted for United States needs.

Port and Transport Developments.

The two big steel companies, U.S. Steel and Bethlehem, had both gone into the Venezuelan market but although the mines were fairly close to each other and the ore in both cases was shipped on the Orinoco River, the two companies had chosen different solutions for handling the traffic. Bethlehem had built a number of smaller vessels to bring the ore down to the river mouth, where they had arranged a transhipment station at Puerto de Hierro. Here the ore was reloaded into big units of the Bethlehem fleet for the passage to the United States ports. U.S. Steel had accomplished extensive dredging of the river in order to enable big units to get up to their newly constructed port at Puerto Ordaz. They were thus able to arrange direct shipments to United States ports. Long term arrangements had been entered upon with different interests in order to ensure these shipments and the three biggest ore carriers in the world had been put into the service. Enormous investments had been made in Venezuela by these two companies and in the near future Bethlehem would ship up to three million tons and U.S. Steel about six million tons annually to United States ports.

Reviewing what had been achieved in the Labrador region within about four years, Mr. Brusewitz said that a 580-km. long railway had been built out into complete wilderness and a modern port with great capacity had been constructed at Seven Islands from where shipments started in 1954. It was to be expected that in the near future about 10 million tons per year would move from this port principally to various destinations in the United States. The increase in total volume called forward by the new "oversea" mines was clearly indicated by the figures of United States imports of iron ore. In 1938 the figure had been 2.2 million tons. It was to-day 18 millions and was expected to reach 25 million tons in 1960.

Baltic and International Maritime Conference—continued

Steel Consumption in Europe.

In the United Kingdom the figure for steel production had risen from 10.6 million tons in 1938 to nearly 19 millions in 1954. As to the Schuman countries, the corresponding figures were 33 and 43.8 million tons. Domestic ore supplies still played a decisive part as production basis in the different steel industries, but with the increasing demand called for by higher productive capacity of the different steel industries, they were also witnessing different endeavours to fill the margin from established, as well as from new iron ore sources. The productive capacity of the main Swedish mines would in the near future, by modernisation and other measures, reach a figure representing more than 150 per cent. of their pre-war export capacity. The same applied to the iron ore deposit of Wabana. But this was not sufficient. The British iron and steel industry had therefore gone oversea and especially taken an interest in the development of new sources in West Africa. There were also French and Spanish investigations being carried on on the West Coast of Africa. Quite a few deposits were known. If some of those deposits were to become competitive factors in the struggle to give an ever-increasing steel industry its raw material basis, not only the transport from mine to seaport, but also the seaborne movement had to be solved in the cheapest possible way.

Summarising how the new deposits were affecting the seaborne movements of iron ore, Mr. Brusewitz concluded as follows:

(1) In the years to come new vast iron ore deposits oversea would enter into the picture as raw material suppliers to the rapidly increasing iron and steel industry of the world.

(2) This would mean a corresponding increase in the seaborne movements of iron ore and thus in the demand for shipping space.

(3) It was however, obvious that the dominant part of this increase would come in the United States sector where deposits and steel works were controlled by the same interests. Those interests were taking every measure to ensure exploitation and transport in the cheapest possible way.

(4) The same factors as in (3) also partly applied to the European sector. Where the interests were not related to each other, steps had here been taken, not only by consumers (Biscore with a fleet in being so far of 19 ships and the big German interests) but also by producers—especially in Scandinavia—to ensure shipments at low costs in highly specialised vessels. Both in the United States and Europe the trend was to arrange shipments in the biggest possible units in order to keep costs of transportation as low as possible.

St. Lawrence Seaway and Overseas Trade

A review of the probable effect of the St. Lawrence Seaway on international shipping was given in an address by the Hon. Lionel Chevrier, Q.C., president of the Great Lakes—St. Lawrence Seaway and Power project.

After giving a brief account of the historical background of the Seaway and of the negotiations between Canada and the United States, Mr. Chevrier gave details of the development scheme*, and then proceeded to deal with the probable international effect of the project. The following is an abstract of this part of his address.

The importance of the St. Lawrence Seaway, providing deep water transportation nearly half-way across the Continent, is difficult to over-estimate. In the first instance, the Seaway project cuts through the heart of industrial North America. Over 60 per cent. of the Canadian population is located in the provinces of Ontario and Quebec adjoining the Seaway. These two provinces account for nearly 80 per cent. of Canada's manufacturing and processing capacity. Similarly, the eight states adjoining the Seaway on the American side, contain 35 per cent. of the U.S. population. Over one-half of the value added to products by manufacturing, is attributable to the industries of these states.

Secondly, the Great Lakes-St. Lawrence system will permit the movement of many of Canada's rich, though widely-scattered natural resources, not only to the industrial regions adjoining the Seaway, but to other North American and overseas markets, by economical water transport.

There is every reason to expect that the through movement of grain by large efficient vessels, will not only expedite the whole shipping process by avoiding trans-shipments, but also will decrease the total shipping cost by from three to five cents per bushel at Montreal or other ocean ports.

Iron Ore Shipments.

Another large-scale movement that has been developed within the confines of the Great Lakes system relates to the shipment of iron ore. The Seaway, by permitting the flow of iron ore up the St. Lawrence without trans-shipment, will assist substantially in developing a market for the basic minimum production requirement of 10 mn. tons per year. Thus, the Seaway will not only aid the development of Canadian enterprise, but by reducing the necessity for resort to the less suitable ore bodies in the Mesabi Range area, will postpone increases in iron ore costs (in the Great Lakes region) with their inevitable effect upon finished steel prices.

Estimates of the traffic which will utilise the Seaway in the years immediately following its completion suggest a total of 30 to 35 mn. tons of cargo per year. This may be compared with approximately 10 mn. tons currently passing through the St. Lawrence Canals.

It is anticipated that about 60 per cent. of this traffic will take the form of grain and iron ore movements. Petroleum products, coal and coke, and forestry products may prove to be the leading secondary items of transport. According to some estimates they may account for as much as 25 per cent. of the local traffic. These items—grain, iron ore, coal and coke, petroleum and forestry products—possibly amounting to as much as 85 per cent. of the immediate tonnage potential of the Seaway, may broadly be considered to represent internal North American trade—basically an extension of existing movements.

Great Lakes Overseas Trade.

In contrast to this type of traffic, there is the movement of cargoes of both a bulk and a general merchandise nature which is primarily associated with trade between the industrial districts adjoining the Great Lakes-St. Lawrence system and overseas areas. This overseas trade is possibly the most interesting facet of the Seaway traffic potential. While initial volumes of such cargoes are expected to be small relative to the "internal" bulk movements, estimates are hampered by a lack of long-term experience, and may not reflect the ultimate market for this traffic.

Re-established in 1945, the Great Lakes-overseas trade has since expanded at a phenomenal rate. By 1954, the total volume exceeded 780,000 tons, and involved 14 shipping lines and 120 vessels. It is worth noting as a measure of growth that the number of shipping lines involved doubled between 1952 and 1954. This has been accomplished despite the handicaps of the existing 14-ft. canals.

Paralleling the establishment of regular cargo line service by large shipping interests centred outside of North America, tramp steamer services have developed rapidly in this trade over the past six or seven years. This factor, too, holds promise for the future. It offers assurance of adequate services to ports too small to warrant regular services, and also indicates the development of charter services and intensified odd-lot, low-value freight cargo.

If trade within North America between Canada and the United States is excluded, total combined imports and exports of the United States and Canada amounted to approximately $24 billion in 1953. Of this, approximately $10 billion represented trade with Europe. It may be expected, then, that the existing direct Great Lakes-overseas trade will follow this pattern. Indeed, available figures indicate that the principal trade route for traffic finds its eastern terminus in Europe. While the Northern European districts presently predominate, there is evidence that trade to the Mediterranean area is increasing. Limited services are also operating to the west coast of Africa, and, quite recently, there has been an extension of routes into the Caribbean.

The completion of the Seaway should not only bring an intensification of trade over existing arteries, but possible extensions to the east and west coasts of South America, the east coast of Africa, the Middle East, India, and possibly Indonesia and other East

* Articles on the St. Lawrence Seaway have appeared in this Journal for November/December, 1950, and April, 1955.

Baltic and International Maritime Conference—continued

Indies Islands. It is to be expected, however, that traffic with Northern European nations will predominate. These nations may offer the greatest route advantages in relation to the position of the Seaway. Furthermore, the water haul from the majority of Great Lakes ports to North-Western Europe is actually shorter than the combined railway-ocean shipping routes involved in transport from the Great Lakes, via U.S. coastal ports.

The relatively small but rapidly expanding Great Lakes-overseas trade, with its infinite varieties of general cargo, appears to offer the most attractive future for ocean vessels. This traffic may be trans-shipped at the principal ports of the St. Lawrence, or may move directly by ocean vessels, depending upon the relative costs of transportation at the time the movement takes place. Canadian and U.S. participation in this through traffic is currently small and may be expected to increase with the completion of the Seaway subject to trade conditions, traffic patterns and the like. Nevertheless, there appears to be ample scope for other world-wide shipping interests of all types.

Estimates vary considerably, but there is substantial reason to believe that the present volume of this traffic (over 500,000 tons) will more than treble in the years immediately following completion of the Seaway. The estimation of the ultimate volume of such traffic would amount to sheer speculation. Suffice it to say that the Great Lakes-overseas trade now constitutes only an insignificant fraction of the total waterborne trade between U.S. coastal districts and related foreign areas. It could be expanded some 25 times its current level without exceeding the tonnage of similar traffic now handled by ports in comparable U.S. coastal districts.

The Annual Report

The annual report of the Conference, which was approved at the general meeting, covers the period since the Conference meeting at The Hague in June, 1953. It states that the membership of the Conference continues to grow and that three Continental associations whose members are principally interested in motor coasters which play an important role in several European short-sea trades had been admitted as club members.

The report contains a comprehensive review of the many problems which have called for the attention of the Conference. Dealing with the progress made in the adoption of the Convention for a uniform system of tonnage measurements (which, in the main, introduces the British measurement system) the report, after recording its adoption as from the beginning of 1955 by Denmark, Iceland, the Netherlands, Norway and Sweden, comments: "On many occasions the Conference has emphasised the desirability of a uniform measurement system to cover all countries throughout the world to substitute any special rules adopted by various countries. Such special rules have always been a source of much irritation and caused many protests. For this reason, the reform as now introduced is welcomed and it is hoped that other countries which still have rules of their own will follow suit and adopt the new Convention for a uniform system of tonnage measurements for ships. Moreover, it appears desirable to have the measurement rules of the Suez Canal and the Panama Canal adjusted in accordance with the new Convention."

The report goes on to say that there is still much confusion in respect of requests for bills of health, payment of sanitary dues, delays to vessels for medical inspection, etc., not permissible according to the International Sanitary Regulations, which came into force on October 1, 1952.

This fact appears to be overlooked by the local medical health officers in some countries and ports. They, of course, have had a certain income and power in the past, thanks to the national practices which should now no longer apply. Nor is there now any necessity for "free pratique" being demanded in countries that are signatories to the convention.

"It is evident," the report adds, "that the expression 'free pratique' in charter-parties has no longer any practical significance and should no longer be invoked in regard to commencement of loading or discharging. The sooner all shipowners and shipbrokers realise this, the better, and the sooner will the expression, and what it has stood for, be stamped out."

New President Elected.

At the concluding session of the Conference, Mr. E. Hahn-Petersen, vice-chairman of the Danish Ship Owners' Association, and chairman of the executive committee of the conference, was elected president for the ensuing two years, and Mr. Birger Krogius, of Helsinki, was elected president designate. The next conference —in 1957—is to be held in Paris.

Before the end of the meeting, a resolution was adopted on flag discrimination and the freedom of the seas. The conference expressed grave concern at the continued increase of flag discrimination, and recorded its firm belief that in times of peace it was in the real interests of all nations, whether directly interested in maritime trade or not, that the policy of the freedom of the seas should be maintained, and that ships of all flags should be free to trade to all ports of the world on equal terms. The resolution also urged that all Governments and international organisations concerned should work to that end.

Correspondence

To the Editor of *The Dock and Harbour Authority.*

Dear Sir,

It seems to me that the review of my book "Coast Stability" on page 298 in your issue for February last, may have misled some of your readers. I shall be glad therefore if you will publish the following:

(1) The book is not issued by "Atelier Elektra" but by Danish Technical Press, Copenhagen V.

(2) Only very little of the book (which consists of 380 pages) has been printed in "The Dock and Harbour Authority" before. Only one chapter (40 pages) was presented at the International Navigation Congress, Rome, 1953.

(3) Your reviewer writes that the main part of the book deals with model experiments. The fact is that about 300 pages deal with actual problems and field experiments.

(4) He also writes "In common with most American investigators, he ignores the centuries old works of Europeans." The fact is: 300 pages deal with *Danish* Coastal Morphology Science; 80 pages with Coastal Protection. The mentioning of Danish, Dutch and English coastal protection includes 26 figures; American, 0 figures. The chapter about groynes decribes Danish, Dutch, English, Italian and German practice and results. On page 152 the reader will find 12 lines about American results, after which the author, in 9 lines, explains that the "new" American idea is an old English idea. In the chapter about "Breakwaters for Coastal Protection" the following is said on page 1: "One finds some of the biggest and most well-constructed sea walls in England." On page 2: "Impermeable sloping walls are generally used in Holland, and probably were developed to protect the foot of dykes in an economical and effective way. The stepped walls are of Dutch origin. The technique is highly developed, cf. the walls in North Holland, the Zuiderzee dam, etc., and it is still being developed. Also in England and U.S.A. remarkable new constructions have been built." After this 3 English and 1 Danish wall are mentioned. Reference is made to American, Belgian, Danish, Dutch, English, French, Italian and Spanish literature.

(5) In the "Introduction" (5 pages) is mentioned the great efforts and progress which have been made in the coastal morphology and littoral drift technology in the U.S.A. in the last 20 years. As regards coastal protection, the author only mentions Denmark, Great Britain and the Netherlands.

(6) Concerning model experiments this is one of the ways in which progress is now made all over the world in the Coastal Engineering field.

Coastal Engineering Laboratories,
University of Florida, U.S.A.
6th May, 1955.

Yours faithfully,
PER BRUUN,
Dr. Tech. Sc.

Commodity Infestation in Ports

V.— "Good Warehousekeeping"

By W. McAULEY GRACIE
(Director and Chief Adviser of Disinfestation Limited).

The author is very conscious that he might be regarded as presuming greatly when offering comments on good warehousekeeping. It may disarm criticism on this ground, however, if it be explained that much of what is written here is already well understood by the good warehousekeeper. It may not be taken amiss by that good warehousekeeper, as he may feel that there is merit in that which he already knows being imparted to others, who may benefit from being brought into possession of information which may be of help to them in their vocation.

The possession of a structure capable of holding a volume of goods and the reception into that structure of goods for storage under contract, is only at the beginning of the art and practice of good warehousekeeping. Indeed, this is a very complicated art, of which the aspect in relation to commodity infestation, although very important in itself, is but a small part.

It is well known that imports of commodities of many kinds are governed as to their volume by seasonal availability rather than by rate of consumer demand. This means, of course, that quantities largely in excess of immediate requirements have to be imported and stored for gradual release according to consumer demand. In this connection length of sound storage life is a factor of prime importance. The longer the safe storage life, the greater is the economic benefit due to avoidance of untimely release of stocks "to save their lives". It follows that considerable importance attaches to the type and condition of storage accommodation, and the plans of stowage must have a direct bearing on the economic storage life measured according to the varying "keeping" requirements of the different classes of commodity.

It cannot be denied that in many old established ports there is a high proportion of warehouses which fall short, judged by modern standards, of what is requisite for reliable storage. Similarly within individual ports, the standards may vary widely and be out of relation to what is really essential for proper storage of high quality commodities. In the past there have been attempts to classify port warehouses generally according to their suitability for particular merchandise, but arrangements of this nature have usually broken down when arrivals of cargoes have occurred in excess of the available storage space scheduled for the particular commodity. Consequently, the balance has had to go into structures which had space to accommodate it, although that space was less suitable than the circumstances merited for housing the particular commodity.

The pressure for storage space has at times, and particularly during the war period, been such as to result in unsatisfactory improvisation and utilisation of substandard structures. Whatever might have been justified under conditions of emergency, such practice if continued in normal times as a competitive operation is much to be deprecated and could only result in generally depressing an industry which should be engaged, as it already is in large measure, in maintaining and improving standards of provision and performance.

Good warehousekeeping consists in the main in providing optimum conditions for ensuring full length storage life and ultimate delivery in satisfactory condition. In this connection the condition of the structure, the adequacy of the ventilation, the control of the temperature and humidity are physical factors of great importance, whilst the cleanliness of the structure and its freedom from dirt, debris, junk and litter are essential ingredients in any claim to satisfactory storage conditions.

From all time and in all countries, man has been concerned with the problem of grain storage, and the methods of storage have been largely governed by the stage reached in the development of organised society. Failure to conserve stocks has repeatedly brought disaster to communities and produced famine conditions when harvests were bad. In an area so densely occupied as is the United Kingdom, a substantial part of the grain requirement has to be met by imports, and the head of supply which forms the reservoir for current and future needs is to large extent the special care of the warehousekeeper, particularly in the ports. Upon him falls the responsible duty of safeguarding these stocks.

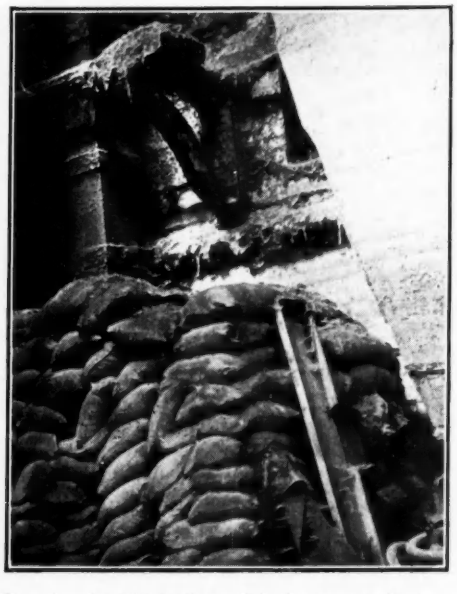


Fig. 1. An illustration of bad stowage in unsuitable accommodation, in contrast with Fig. 2.

In an article of this nature it is natural that special emphasis should be laid on grain storage, but it is important, too, that other foodstuffs susceptible to deterioration, and many other commodities essential to our well-being, must be under prudent and careful stewardship up to the time of their release into the pipeline of commerce and industry.

It is to be accepted that good commercial practice requires that anyone receiving commodities into his ownership and care should satisfy himself, in his own interests, of their quality and condition. Subject to that general principle, the opportunity for preventing the spread of infestation can only be taken if parties to the transfer of commodities or the utilisation of storage and transport equipment do not conceal from the transferees knowledge acquired during their custody or care of the presence of infestation in the commodity or the structure as the case might be. It is bad enough when the effect of concealment upon the transferee is considered, but it is to be much more deplored when concealment results in the fanwise spread far and wide of the infestation from a single originally infested parcel. It will be well within the minds of many port warehousekeepers that in the early days of the last war a single cargo distributed over many warehouses produced general infestation of structures and commodities within the particular port, and also inland.

Sufficient has been said in previous articles in this series to illustrate the various types of infestation of commodities and in the present connection it is proposed particularly to discuss the means by which, without proper care, infestation and infestation damage may be spread in the course of warehouse practice. The reader who may not have direct experience of warehousing, cannot fail to be impressed with the burden of discovery, precaution and protection involved in good warehousekeeping, and on the whole discharged surprisingly well.

In the first instance, it is in the interest of the warehousekeeper himself and of his clients that he should be satisfied that his buildings are clear of residual infestation. He will, or should, maintain close inspection of floors, walls, ceilings, wall fillets, as well as hoists and chutes and ensure that all crevices, cavities, etc., are free of pests which might otherwise emerge on the introduction of fresh commodities into the warehouse. He will also make certain that leaky roofs,

Commodity Infestation in Ports—continued

Fig. 2. An example of good stacking with neatly arranged alleyways which facilitate inspection. Even in this case the alleyways could, with advantage, have been somewhat wider to enable control action to be more readily introduced.

damp walls, broken windows, etc., are all made good and that the storage accommodation is cool, clean and dry.

Those matters being all found to be in order, his real problems commence with the introduction of commodities for storage. It is well that he should, if possible, know something about the origins of the commodities he receives into his premises, so that he may determine whether the particular trade has a known infestation risk. In any case, his skilled staff will be keeping a sharp lookout for external evidences of internal infestation in commodities tendered for storage, and if such evidences are found, then he will or should consider the course he will take in justice to his other clients and their commodities and to himself in his duty to them and in his own protection as the occupier of the premises.

It is never to be forgotten that it is far easier to acquire infestation and to have it spread itself over the entire structure and its contents, than to get rid of it once it has become established. It is therefore imperative in the warehousekeeper's own interest that his inspection should be strict, and his action prompt on discovery that infestation has entered his premises and is at work. He cannot afford to ignore the evidences, however slight they might be, because the minor infestation of today may be a major infestation tomorrow.

Nor is he safe in assuming that an infestation noticed at the latter end of the year may be ignored on the basis that the insects will not survive the winter, in an unheated warehouse. In this country, with its unpredictable climate, internal temperatures provide no guarantee against over-wintering by some kinds of insects. Indeed, some can live in unheated warehouses throughout the winter under normal conditions here, and others have a chance of survival under the particular conditions in individual warehouses.

The risk of introduction of insect infestation into a warehouse may not be limited to entry in the host commodities. There is ample evidence that certain insects, either windblown or flying from adjacent infested premises, may enter through open windows and doors and start up new activities. They might also be transferred on the wearing apparel of persons moving from infested to uninfested premises. The author recalls one case where an Entomological Inspector was being challenged by a commercial manager on the accuracy of his identification of insects present in the commodities in the warehouse adjacent to the office block. He was able to illustrate his point by selecting from his trouser turnups and from his socks, specimens of the various creatures in dispute. This is not recommended as an appropriate way in which to carry live specimens from place to place, but in the particular case it had its useful side.

The rapidity with which insects introduced in a particular commodity find their way to the other contents of the structure is most disturbing. The rate of multiplication also adds greatly to this "colonisation". It is recalled that in a certain warehouse where bulkhead boards formed the side of a bulk grain bin, the rate of multiplication of the weevils present was so great that they literally poured out between the bulkhead boards and formed a ridge along the warehouse floor about an inch deep and then spread out in their trek to other harbourage and food.

In the whole field of infestation control there is no other problem so serious as that of cross-infestation. This is the name given to the exchange of pests from one commodity or one parcel of a commodity to another commodity or parcel and may occur at any and all of the stages of carrying, aggregating, storing, and distributing. In particular it is the concern of the good warehousekeeper lest a relatively small parcel of infested material unwittingly received into storage spreads infestation to all the stocks in his custody.

The good warehousekeeper will always set his face against knowingly receiving infested commodities into storage. In the past, cases have been known where, probably under stress of competition, warehousekeepers either have, with their eyes open, accepted infested goods into storage in premises which contain clean commodities, or have set apart a structure, probably more or less separate from the main body, entirely for use for storage of infested commodities. Either system gives rise to special risks, much better avoided. In the author's experience cases have occurred where infestation of sound stowages has been attributable directly to the barrowing of infested materials for stacking at more remote parts of the structure through the clean section. That can only be classed as culpable negligence. In the second type of case, i.e., where a particular building or separated section of the building is given over to the storage of infested parcels, the intention may have been good and in conformity with certain views on the necessity for segregation, but in the result the general cross-infestation left each parcel so housed with a vastly increased range of insect pests beyond what it brought with it. It is small wonder that when such deeply infested commodities ultimately were delivered they were a ghastly risk to all premises, equipment and commodities with which they came in contact, and the evil train they left behind them served also to contaminate commodities which might follow along the same route. So much for cross-infestation. Avoid it as the plague!

The good warehousekeeper will do well to keep a special eye on the methods of dealing with used grain sacks about his premises. The hiring out of sacks for the storage and conveyance of cereals is an important ancillary in the grain trade, but the system needs to be under strict supervision in relation to the condition of the sacks, if there is to be any assurance that such sacks are not likely to become a serious potential risk as carriers of infestation. This argument applies in greater or less degree, according to their previous history, to the general re-

Commodity Infestation in Ports—continued

use of sacks. Sacks should be thoroughly cleaned with due attention to the seams and turnovers, where insects may have pupated or may be in the diapause or resting stage. This cleaning should be meticulous and thorough and, where necessary, fumigation or steam heating should be resorted to. In particular it is simply asking for trouble to allow empty grain sacks to be piled on floors which are used for the storage of grain. The sacks should be kept in entirely separate accommodation with a further separation between cleaned and uncleaned bags.

The warehousekeeper has to teach himself to expect the unexpected in the causes of introduction of infestation into his premises. The following illustration is based on an actual occurrence, but is slightly adapted to fit the circumstances. Insect infestation which occurred in an important industrial factory was traced to a consignment of tinplate which had been received into a section of that factory. The railway truck which carried this tinplate over a distance of more than two hundred miles from the tinplate works had, on a previous trip, carried provender imported through a port, for the pit ponies at a colliery adjacent to the tinplate works. The original infestation was in that imported provender; it had left a residual infestation in the railway truck, the insects became passengers on the tinplate sheets themselves and were delivered into the factory at the destination along with those sheets. It might not have mattered very much if those insects had got no further than the section to which the tinplates were delivered, but as they did get into a food producing section, the case was indeed a serious one. The warehousekeeper should even be suspicious of any dunnage which may be reused in forming the base of the commodity piles, as this dunnage may well be supporting a large population.

Fig. 3. Used grain sacks should not be stored on the warehouse floor where grain is housed. Used sacks may be the harbourage for large numbers of insects and may also spread them to the structures and the contained commodities.

At this stage it would be convenient to leave for the time being the further consideration of types of structure and methods of stowage, in order to turn attention to the connection between the origins of grain and the probable degree of infestation according to those origins. In approaching this brief study, we might remind ourselves that the damage attributable to pests extends far beyond the amount eaten by them, be they insects or animals. In the case of insects and mites, it has already been seen that mites, beetles and moth grubs, bore into and eat the germ of the grain. Other boring insects, and particularly weevils, attack the endosperm and cause loss of weight and poor rate of extraction. Mites and some beetles when present in considerable numbers may cause a taint to the grain, which persists through the milling process to the finished materials. Insect attack figures prominently in the heating of grain, and this heating may be the cause of mouldy and musty taint and, in extreme cases, discolouration of the germ and damage to the gluten may be found.

It follows from what has just been said that the more infestation that is present in grain, the greater is the damage done to the grain, and therefore that the greatest liability to damage is to be expected in grain originating in territories most favourable to the development of insect pest populations, that is to say, the hot countries. So far as the United Kingdom is concerned, storage pests are not to be found in the growing crops, and it is only when home produced grain becomes infested in grain drier plants, transport equipment, or infested storage that the trouble arises.

In the tropical areas, the Rice Weevil (*Calandra oryzæ*), the Lesser Grain Borer (*Rhyzopertha dominica*) and the Angoumois Grain Moth (*Sitotroga cerealella*) are of special importance, while in the temperate zone, stored grain is mainly attacked by the Grain Weevil (*Calandra granaria*), the Saw Toothed Grain Beetle (*Oryzæphilus surinamensis*), the Rust Red Grain Beetle (*Læmophloeus ferrugineus*) and the Flour Mite (*Tyroglyphus farinæ*). In addition, the several moths, by their grubs, cause considerable damage to the germ of grain.

It has to be remembered that clean grain will not remain clean if it is placed into holds of ships which are infested, nor if it is loaded with other commodities which may be carrying infestation. In illustration of this point, it may be said that the practice of the Canadian Department of Agriculture to inspect the holds of ships prior to loading and to require appropriate cleansing action to be taken before grain is loaded, has been a major contribution to the clean entry of grain into the United Kingdom. The fact remains, however, that grain shipped from Western Canadian ports, when over-stowed with timbers, may become infested with fungus beetles and mites. The Rust Red Grain Beetle also may be encouraged in its development in warm grain stowed against warm bulkheads. It has already been suggested that the good warehousekeeper should know something about the origin of the grain which may be tendered to him for storage, and these notes may serve to remind him of the justification for this particular care.

It will be realised that the risk of infestation being acquired by grain is dependent

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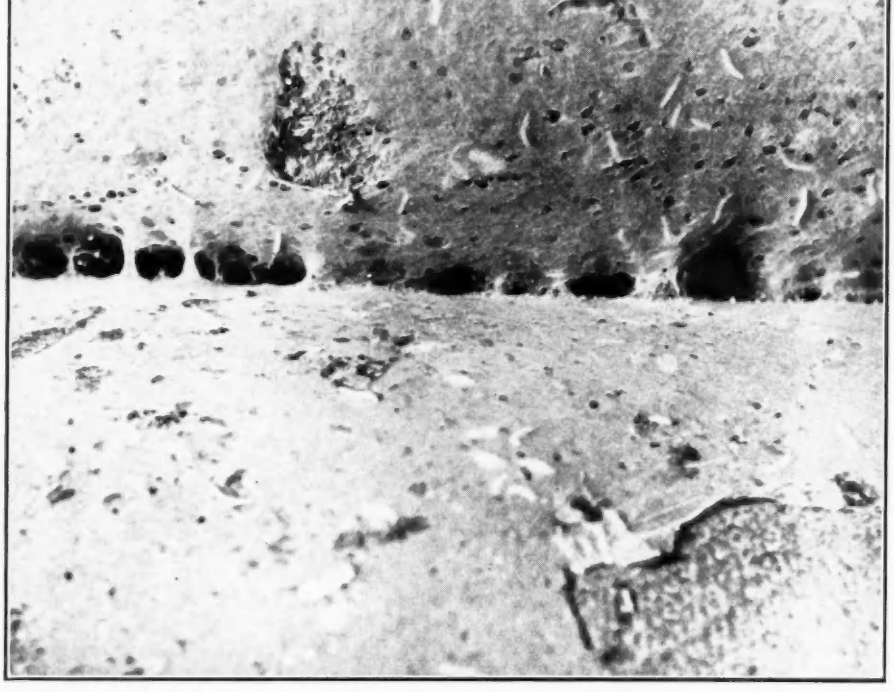

Fig 4. A good example of the silk cover which the grubs of the food moth (Ephestia elutella) may spin completely enclosing sacks of grain.

Transport of Maritime Cargo

A Study of Operations from Shipper to Consignee

THE finding of ways and means of turning ships round more quickly is exercising the ingenuity of port operating officials in maritime countries all over the world. There is no doubt that the problem is one of the most vital and most difficult the shipping industry has to face and it is one towards the solution of which "all contributions are thankfully received."

A useful contribution has recently been made by the Maritime Cargo Transportation Conference of the National Academy of Sciences — National Research Council, Washington, U.S.A., which is engaged in a programme of study for the purpose of "providing guidance on means and techniques leading to improvement in the sea transportation of general cargo." Results of the initial study in this programme have been published by the Council under the title "The ss. 'Warrior'" (National Research Council publication 339, 30.11.54—price 1 dollar per copy). This interesting book deals with one complete voyage of a general cargo vessel between New York and Bremerhaven (Germany) and data collected have been collated in seven separate "segments," viz. (I) Domestic Movement (of cargo to the port of New York), (II) Receipt and Storage (at the port premises), (III) Loading, (IV) The Voyage, (V) Discharge, (VI) Receipt and Handling (at Bremerhaven) and (VII) Delivery (from port premises).

The ss. "Warrior" (Watermen Steamship Corporation) was chosen for the study because she is a typical general cargo vessel (with 'tween and shelter decks, deep tanks, etc.) and on the voyage concerned, in March, 1954, she was carrying a typical cargo of mixed goods. She is 496-ft. long (overall), she has a 63-ft. beam and a full draft of 27-ft. 6-in. Fully laden she can carry a little over 5,000 tons deadweight of cargo. During the voyage in question, her cargo consisted of 4,690 tons of mixed goods—bags, cartons, boxes, cases, etc.—and 325 tons of vehicles on wheels.

The study interprets most of the data in terms of time and money expended and although the conclusions drawn are of necessity tentative and general, there is much in the context of this book to provoke organisations connected with shipping to make a careful examination of this or that aspect of the working of their own and kindred bodies. For example, for many years there has been concern by shipping companies at the big percentage of their total outlay which is spent on ships in port. In pre-war years it was perhaps 40 per cent., now it is said to be nearer 70 per cent. Thus the analysis given of time or money expended on handling goods in port sheds and into or out of ships will concentrate attention again on this particular matter.

The study commenced, as already stated, with data collated under the first heading, the domestic "segment," but it may well be that to readers of the "Dock and Harbour Authority" this is the least interesting part. However that may be, there is no doubt that the remaining sections which cover the conveying and handling of goods on to the pier at New York until they were finally placed in transit shed at Bremerhaven will be of great interest to port operating organisations and thus the review which follows concentrates mainly on these "segments."

In the introduction to the ss. "Warrior" the objectives of the study and the system employed were stated as follows:

"Objectives. The objectives of the "Warrior" study are to select a transportation system, identify and describe its components, document an actual movement of general cargo through such a system and analyse the results. Based upon such analysis, conclusions might then be made as to the components or areas in the system which offer the most fruitful fields for improvement designed to reduce the turn-around time of ships. Finally, methods for achieving such improvements might be sought, applied to the system theoretically and the effects computed. Practical tests may follow. A secondary objective is the development of a methodology for the analysis of systems.

The System. The military system from U.S. depots and manufacturers through the New York Port of Embarkation, Brooklyn Army Base, to consignee depots in Europe through the Bremerhaven Port of Embarkation was selected as the subject system for this study. This particular pipeline was chosen because: (1) The Army offered immediate access to all operations and documentation; (2) a complete shipload of general cargo, to include some vehicles, was ready for loading; (3) the Army-Air Force re-supply cargo common to this route is similar in nature and stowage factor to many purely civilian-type general cargoes;

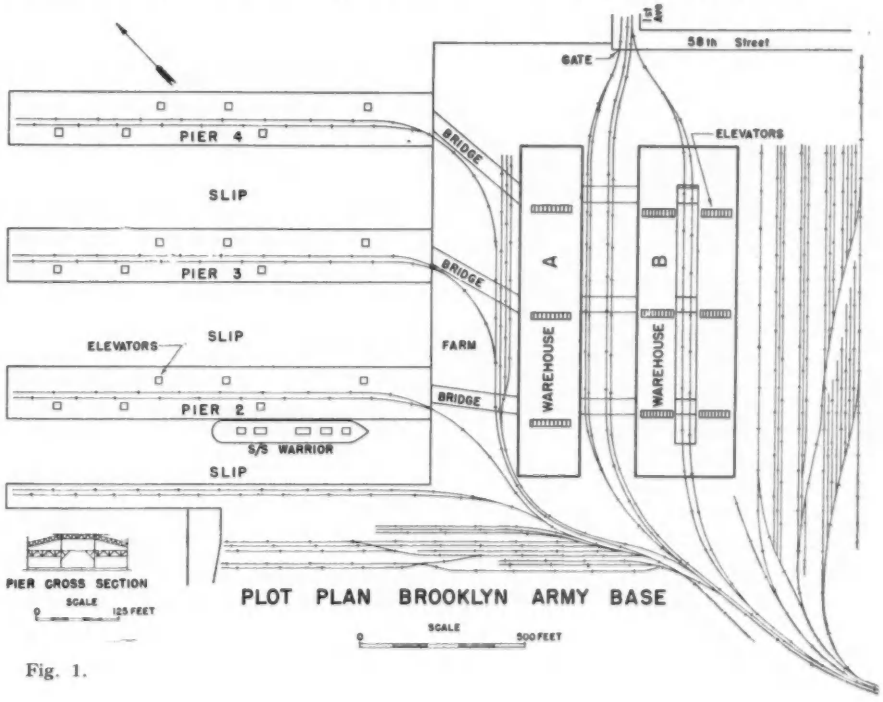

Fig. 1.

Commodity Infestation in Ports

(continued from previous page)

primarily upon the likelihood of its being contaminated when using storage or transport accommodation or facilities or being brought into contact with already infested commodities.

In general, the warehousekeeper would do well if, as far as is practicable, he takes care to see that parcels of grain, etc. of different origins are stowed separately, and that there are sufficient alley-ways between the piles to enable inspection and probable treatment to be given to affected piles, thereby preventing spread of infestation generally throughout the premises.

It should not be necessary in the present connection to stress the need of efficient rat proofing of the structures, but a word might be said at this stage by way of illustration of what may unwittingly be done for the comfort and encouragement of mice! In one large food store a stock of hollow bricks had been ranged along one of the internal walls and had become a well occupied block of flats for mice—optimum harbourage indeed!

The next article to appear in this series also will deal with "Good Warehousekeeping".

(to be continued)

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Transport of Maritime Cargo —continued

(4) the cargo was to be loaded in a commercial bottom; (5) a one-port loading for a one-port discharge offered a relatively simple case to monitor and describe; (6) all loading operations were to be performed by civilian contractors using union labour; (7) the New York Port of Embarkation and the Bremerhaven Port of Embarkation are quasi-industrial installations in which cargo operations are analogous to civilian cargo operations; (8) practically the entire cargo was moved to the New York Port of Embarkation by commercial rail, truck and lighterage services. It is believed that the system selected is very similar in all important respects to an average commercial transport system."

Segment II (Receipt and Storage) begins when the domestic carrier arrives with his goods in the port area and terminates when the consignments are finally stowed in the New York pier transit shed, from which they will subsequently enter Segment III, the loading phase.

The " Warrior " was berthed at a double-decked enclosed pier 1,295-ft. long and 150-ft. wide (Fig. 1). Ground floor height varies between 19-ft. and 25-ft.; first floor, between 14-ft. and 26-ft. There is good access for mechanical equipment and for railway wagons on the ground floor. Access for fork-lift trucks, tractors and trailers, etc., to the first floor is by means of a bridge (from warehouse "A" on the plan) and there are also six goods lifts. There are no pier cranes but housefalls are available.

All movement of cargo about the terminal from point of discharge of domestic carriers to final stowage in shed was accomplished by the mechanical appliances mentioned. In the " Warrior " loading (Segment III) except for ship's stores loaded through a side port, the quay cargo (all of which was palletised on pier-pallets) was moved to the ship's side by fork-lift truck and was lifted aboard by means of ship's gear used in conjunction with the housefalls. Only two fork-lift trucks were required to feed the hook at each of the five hatches. For loading heavy lifts, the ship's gear was doubled-up. No difficulty was encountered using ship's gear to pier, as the tidal range was only four to five feet. All cargo loaded from barge was handled by floating crane and consisted of wheeled vehicles.

Loading was conducted on a one shift (8-hour) basis, 8 a.m. to noon and 1 p.m. to 5 p.m. Monday to Friday.

The fourth phase of the transport system (Segment IV—The Voyage) is mainly dealt with in a special 20-page supplement, which gives a meteorologic and oceanographic analysis of the actual passage. The main idea of this special analysis is to stress how the length of the voyage can be reduced by the intelligent use of weather in ship navigation.

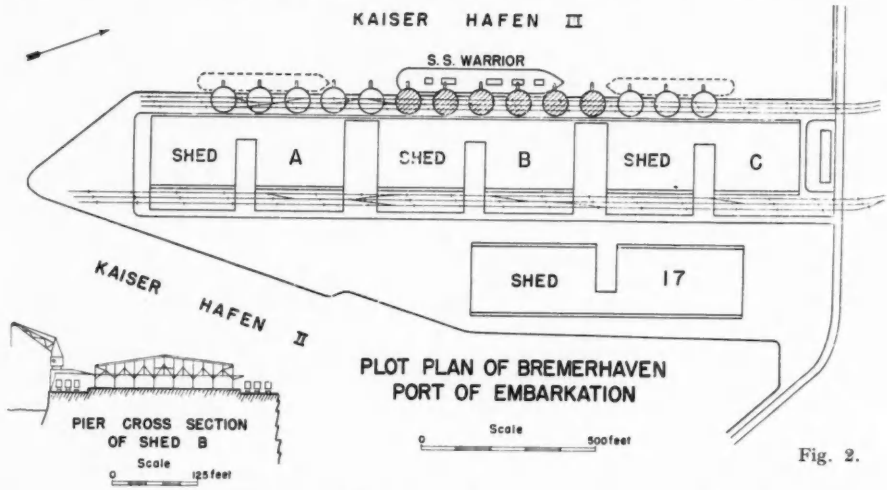


Fig. 2.

The discharge phase (Segment V) begins when the vessel is finally moored at the unloading berth and ends when the last set of cargo is landed on to the quay or put into barge. The " Warrior," upon arrival at Bremerhaven, was moored at Berth B (Fig. 2). This normally has five semi-portal gantry level-luffing electric cranes of 3-tons capacity but, if required, this quantity can usually be augmented from adjacent quays. The quay is 47-ft. wide and it is depressed 3-ft. 9-in. to accommodate three rail tracks and the gantry rail. There is, however, a loading bank 14-ft. wide along the shed front and at shed floor level and the method employed is to feed this direct from ship by the quay cranes. It is, in fact, impracticable to use ship's gear for loading or discharging on the inshore side of the vessel but such gear is, of course, often employed for handling goods to and from craft.

The Receipt and Handling Segment (VI) begins when the set of cargo lands on the quay and ends when all cargo has cleared the port premises. At Bremerhaven, the usual ship's gangs were employed, constituted thus: a foreman, a crane driver and six hold-labourers. The shore gangs employed during the discharge of the " Warrior " used a few tow-tractors and trailers but no other mechanical equipment. In the main, therefore, the quay and shed work was done manually. An interesting table to quote here shows the speed at which the cargo was cleared from port premises.

Long tons	Days held in port
4,258.0	0
7.4	1
16.8	2
25.2	3
335.5	4
273.6	5
88.5	6
10.0	7-29
5,015.0	

The last phase (Segment VII) of the transport system consists of the movement of the cargo from port premises to consignee. Of the " Warrior " cargo, 99.4 per cent. left the port premises by rail; none was taken by water conveyance.

The following table is reproduced as an interesting summary of the data collected.

The s.s. " Warrior "—General Summary of Data Collected.

System Segment	Total LT	Total Cost	%	Long-Ton Miles	Cost Per Long-Ton Mile ¢	Cost Per Long-Ton ¢	(2) Wgtd. Time in Days	Total Elapsed Time in Days	(3) Wgtd. Av. Distance (Miles)	(4) Wgtd. Speed of Advance Miles/Day	Manhours
1. Domestic Movement	(1) 4508	88,957	37	1,326,546	0.0670	---	7.6	52	294	38.6	3077
2. Receipt & Storage	(5) 4690	14,827	6	---	---	3.16	5.9	35	---	---	4980
3. Loading	5015	41,292	18	---	---	8.23	2.9	6	---	---	8235
4. Voyage	5015	27,297	12	21,263,600	0.001	---	10.5	10.5	4240	403.8	3730
5. Discharging	5015	18,185	8	---	---	3.63	2.0	4.9	---	---	(7) 9474
6. Receipt & Handling	5015	12,962	5	---	---	2.58	0.7	30	---	---	(7) 3761
7. Delivery	5015	34,057	14	1,650,537	0.0206	---	3.08	33	329	106.8	Unknown
Totals & Averages	5015	237,577	100	24,240,683	0.0098	47.37	32.7	(6) 97	4833	147.7	38273

(1) An additional 507 LT were generated within the port of loading
(2) Weighted time in days = $\frac{\text{Total ton-days}}{\text{Total tons}}$
(3) Weighted average distance = $\frac{\text{Total long ton miles}}{\text{Total long tons}}$
(4) Weighted speed of advance = $\frac{\text{Weighted average distance}}{\text{Weighted time in days}}$
(5) 325 LT loaded direct from lighter to ship; did not work over pier (all wheeled vehicles)
(6) From departure first shipment from U.S. depot until arrival last shipment at overseas depot
(7) Excludes paid meal period manhours which total 1069 for Segments V and VI combined

Transport of Maritime Cargo—continued

Since, as already stated, expenditure of time, labour and money is one, if not **the,** vital aspect of the matter under consideration, the following three tables have been selected for inclusion in this summary:

(1) *Dollar-days to process one long-ton*

Receipt and storage	18.65	U.S.A.
Loading	23.78	
Discharging	7.25	Germany
Receipt and handling	1.80	

A special paragraph dealing with comparative costs in Germany and the U.S. states that "no factor could be developed to equate U.S. longshore versus German longshore costs on the basis of difference in standards of living in the two countries. Although an exhaustive study has been developed by the Organisation for European Economic Co-operation (O.E.E.C.) which indicates that one U.S. dollar spent on goods and services in Germany will buy $1.60 worth of German goods and services, this 60 per cent. increase in the purchasing power of the dollar applies only to the whole German economy. No such estimate is available for application to the restricted area of the longshore industry alone. In the latter area, it is known that the German longshoreman is among the poorest-paid elements of German labour; in the U.S., the longshoreman is among the best-paid elements of American labour. Based on straight-time hourly wage rates, the New York longshoreman is paid 5.5 times what the German longshoreman earns. Obviously, the O.E.E.C. factor of 1.60 is unsuitable for use in any one area of the German economy; the 5.5 wage differential factor is useful only for equating direct wages to labour and does not take into consideration such element of cost as contractor's profit, insurance or fringe benefits. In short, other than for equating direct wage payments to longshoremen, there is no reasonable conversion factor for relating total German discharge and cargo handling costs to U.S. costs for cargo handling and loading."

(2) *Man-power employed and time occupied*

	Percentage of total	
	Man-hours	Time
Domestic movement	8	23.3
Receipt and storage	13	18.0
*Loading	21	8.9
Voyage	10	32.1
Discharging	24	6.1
Receipt and handling	22	2.1
Delivery	2	9.5
	100	100.0

[*The complete loading gang consisted of a foreman and 22 men, disposed as follows: two fork truck drivers, two (or four) men on the ship's pitch, one hatchwayman, three winchmen (one as relief), fourteen (or twelve) men in the hold. Note: No men in the shed.]

One interesting comparison is that made between the hours actually worked and the hours spent on the berth.

(3) *Percentage of working time to total time on berth.*

	Loading	Discharging
No. 1 hatch	16	18
No. 2 ,,	19	81
No. 3 ,,	22	83
No. 4 ,,	24	95
No. 5 ,,	22	70
*Whole ship	28.5	97

[*The "Warrior" worked 45 hours out of 158½ on her loading berth and 113 hours out of 118 on her discharging berth. Loading was delayed for a whole day, however, because of a labour strike.]

The conclusions and recommendations of the investigating body are interesting and are thus quoted in full:

Conclusions and Recommendations

Based on analysis of the "Warrior" data, "It is concluded that:

1. The maritime general cargo system can be improved most effectively by changes in the Process Segments (Receipt and Storage, Loading, Discharging, and Receipt and Handling).

2. The Process Segments most susceptible to improvement are (a) Loading and (b) Receipt and Storage. That is, the area extending from the gate of the U.S. port terminal to final stowage in the hold of the vessel.

3. The nature of the actions taken in the Loading and in the Receipt and Storage phases will react upon the other Process Segments and in the Movement Segments.

4. Although sufficient data are at hand for the purpose of describing the system and for making a tentative identification of areas most susceptible to improvement, more data are required to broaden the analysis."

"It is recommended that:

1. The staff undertake immediately an intensive study of the Receipt and Storage and the Loading Segments of the system.

2. This study be pursued concurrently along two general lines.

(a) To develop suggestions leading to more efficient performance of segment functions within the existing system through the application of new or different methods, techniques or equipment to the conventional terminals and ships in common use to-day.

(b) To develop suggestions for improvements entailing fundamental changes in the form of the existing system, to include elimination or re-design of some segment functions and the introduction of unconventional concepts of terminal and vessel design, materials handling equipment and cargo-packaging practices.

3. The additional data required for a broader analysis be collected."

With regard to Recommendation 2, port operating officials know only too well that the seeking of improved methods, techniques and equipment is their unending task. As already stated, however, this study, if it does nothing else, will undoubtedly cause many Dock and Harbour Authorities, Shipping Companies, Master Stevedores and other employers of labour, not only to renew their efforts to find new and perhaps unconventional means of speeding ship turn-round but also to see whether certain difficulties apparently inherent in the industry cannot after all be partially overcome even if they cannot be eliminated completely.

Soil Compaction

Application of Vibration to Deep Foundations in Granular Soils

(Specially Contributed)

Stability of Soils.

The resistance of soils to static loading has been exhaustively investigated during recent years and it can be said that in general the phenomena involved are fairly well understood. The effect of vibration, impact or concussion upon soils has also been the subject of a good deal of experimental work and research and has been much clarified.

It is well known that granular soils do not, as a rule, fail because of lack of bearing capacity; if loosely packed however they are liable to settle rapidly and differentially and this in turn may lead to structural failure.

Great depths of fine grained soils with a high porosity such as sand and fine gravels may be subject to serious settlement and such soils may become unstable if their physical structure is modified by subjection to vibrations due to, say, moving machinery, road traffic or pile driving. Sands have been found to be more susceptible to vibrationary loading than clays and more particularly when the sand is uniformly graded. Settlement due to vibrationary loading is many times greater and more rapid than that produced by an equivalent static load and its ultimate value or magnitude is dependent upon the frequency.

The safe bearing capacity is, therefore, usually governed, not by the shear strength (ultimate bearing capacity), but by the compressibility. Thus it can be, and frequently is, increased by compaction to many times its original safe bearing capacity.

A soil which in its loose condition is liable to settle considerably under very small additional loads or vibratory disturbances will by compaction become safe for much heavier loads and vibration.

Many soils can be stabilised, i.e. made denser, by deep compaction and several methods have been successfully applied for the purposes of eliminating settlement hazards and increasing load bearing characteristics. Pile driving over the area to produce consolidation is, of course, the most familiar method and buried charges of explosive may be employed in loose sand strata below ground water level. There are naturally many situations where such methods, attended by concussion might be inadvisable and recent interest in soil mechanics has led to the development of

Soil Compaction—continued

another method of stabilisation—by vibration.

Vibroflotation.

The process of compaction of granular soils in depth by vibration is now carried out by a patented method employing an electrically operated tool which is, in effect, a large scale version of the internal vibrators used in placing concrete. In the method, termed "Vibroflotation," of applying vibration to soils. the compaction is effected by a "Vibroflot," which is a 6-ft. long tube of 15-in. dia., containing a powerful vibrator and several water supply systems for jetting up and down and for cooling. This vibrator exerts a 10-ton centrifugal force when vibrating at a frequency of 1,800 cycles per minute and has the power to penetrate strata which has a density 80 per cent., or more, of its absolute density. Successful operation of the machine requires the discharge of water at different stages from the bottom and top of the vibrator at the rate of 60 gallons per minute at 60 to 80 lbs. per sq. in. The weight of 12-ft. of Vibroflot is about 2 tons.

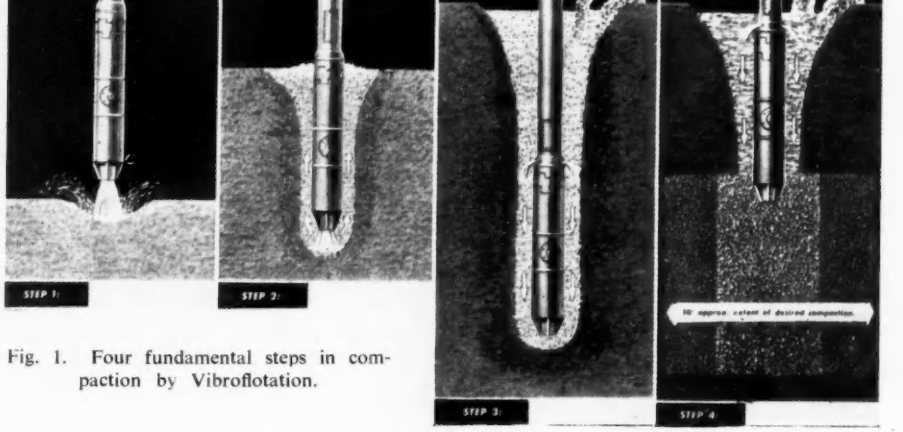


Fig. 1. Four fundamental steps in compaction by Vibroflotation.

The process, invented by Sergey Steuerman about 1935, was first practically applied to thick layers of granular soil in Germany. Extensive research into its possibilities was carried out after the war in the United States of America.

The Vibroflot is fixed to 12-in. dia. follow-up pipes and these are attached to a crane-hook, from which it is lowered and lifted.

A selected pattern of points of application is set out at the site. These are usually in the range of 6 to 10-ft. apart. At each point the following procedure (see Fig. 1) is carried out:—

1. The vibrator is started before insertion into the soil and is allowed to attain full speed. The bottom jet is then opened providing a pool of water and a saturated mass of soil for the vibrator to penetrate.
2. With the jet open full, the machine is allowed to sink into the soil by its own weight to the full depth intended for compaction. Because of the vibration and "upward" movement of the water, a "quick" condition is produced which enables the vibrator to descend rapidly, i.e. at the rate of 10 to 20 seconds per foot.
3. During the lowering of the device into the soil, a precompaction of the material surrounding the vibrator takes place. During this precompaction a cone-shaped crater approximately 3-ft. in diameter at ground level is formed around the adaptor and follow-up pipe of the Vibroflot.

When the machine has reached the desired depth, the water supply to the bottom jet is transferred to the top jets in the adaptor section. The amount of water issuing from these openings is much less than that supplied to the bottom jet and its downward flow helps carry the sand along the sides of the machine to the bottom of the hole. The combined action of the tremendous vibration in the presence of the downward water flow compacts the soil. As compaction takes place the additional clean sand which is shovelled into the crater compensates for the loss of volume caused by the increased density of the soil.

The increasing density is indicated by the rising power input of the electric motor, which is recorded on an ammeter, connected to the vibrator motor and under observation of the crane operator. The more dense the soil becomes, the more resistance there is to movement and therefore the greater the input of power needed to continue the compaction.

When the peak load has been reached, the Vibroflot is gradually raised in stages. Compaction proceeds at a usual rate of 40 to 60 seconds per foot.

4. Actual compaction takes place during the intervals between the one foot lifts which are made in returning the Vibroflot to the surface. The vibrator is first allowed to operate at the bottom of the crater until the desired density around the lower part of the machine is attained. By raising the vibrator step by step and backfilling simultaneously the entire depth of soil is compacted.

By this method a cylindrical compacted column approximately 8 to 10-ft. in diameter is produced. Spaced in overlapping patterns, these columns provide a compacted subsoil of any extent or depth to the required minimum density from bottom to top of the compaction.

Effect of Vibroflotation.

Provided the pattern of points of application is correctly chosen, the density of the total mass of soil is almost uniformly increased. This means that the volume of voids, whether filled with air or with water, is diminished, resulting in an increased weight of solid matter per unit volume. This is normally measured in dry density (lb./cu. ft.).

At the same time the angle of internal friction and consequently the shear strength is increased whilst the compressibility is reduced; the bearing capacity of the strata is increased and the possibility of settlement by consolidation under new loads is greatly lessened. This applies particularly to settlement due to vibratory loads, such as machinery and traffic. One consequence of the reduced porosity is to decrease the permeability of the soil to the flow of water.

Density of Granular Soils.

The density of granular soils is their most useful property. Shear strength, angle of friction, bearing capacity and compressibility all directly depend upon this property, which is usually expressed as the dry density; the porosity or the void ratio of the soil is also used to indicate the density.

The density is related not only to the form of deposition and its past history, but also on the grading of the soil, both in respect of grain size and uniformity of grain size. Coarse sand and sand of mixed grain size generally attain a higher density than fine and uniformly sized sand.

It is important, therefore, to have a scale for the degree of compaction which exists, or can be attained, in a particular soil. For this purpose the Relative Density can be used. When both the loosest and the densest condition in which the particular soil can exist, and also the density of the soil in situ are known, the Relative Density can be determined (see Table).

Granular soils have been found in natural conditions with a dry density of:—

Type of Soil	*In a loose state*	*In dense state*
Uniform sand	80 lb./cu. ft.	109 lb./cu. ft.
Well graded sand	99 lb./cu. ft.	116 lb./cu. ft.
Sandy gravel	100-105 lb./cu. ft.	135-140 lb./cu. ft.

The increase in the angle of friction resulting from increased density also raises the resistance to penetration by piles or sounding tools. This fact enables an empirical comparison of the density by recording the energy required for a given penetration of a standard tool.

The degree of Relative Density required at a particular site must be determined with regard to the prevailing conditions for the planned construction. As a rule for normal loading a Relative Density of 70 per cent. to 80 per cent. produces satisfactory conditions if vibrations have to be considered. When the Relative Density is less than 70 per cent.

Soil Compaction—continued

consolidation by Vibroflotation can still be of definite economical advantage.

The Graph (Fig. 2) shows the relation of Relative Density to the density of a particular sand soil and of sandy gravel, and (Fig. 3) illustrates how the use of vibroflotation increases soil resistance. The additional blows per foot required indicate the greater bearing capacity possible for friction piles.

Proving and Checking Compaction.

There are several methods by which the intensity of compaction can be determined. If actual density figures are required, borings have to be made or trial pits excavated; specimens of the compacted soil can then be obtained and their weight and volume measured.

For an approximate determination of the density, standard penetration tests are normally sufficient. As a rule, however, it will be adequate to check the application of the process by the production of continuous record graphs of the power output. These are measured instantaneously by the recording ammeter, under the direct observation of the operator and are related at each point to the depth of application.

Advantages that can be obtained by Vibroflotation.

A sand or gravel strata which is loosely packed can frequently be piled through without great energy output, so that the piles have to be driven as point bearing piles to a more stable stratum.

If the soil has in consequence of its low density a low skin friction, piles will have to be very long in order to develop the skin friction required for the intended working load.

However, after the stratum has been sufficiently compacted, the angle of friction will be considerably increased† with the effect that bearing piles can be replaced by friction piles of much shorter length, and the friction piles themselves can be considerably reduced in length. Course gravel can become so dense that it becomes impossible to drive piles beyond a few feet.

Where there is a sufficient thickness of granular material on a large area to be compacted, Vibroflotation is claimed to be more economical than any other method of compaction because:—

(1) The operation is quicker.

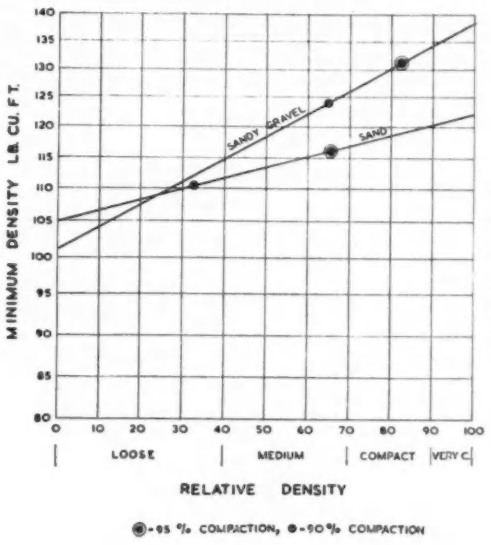


Fig. 2. The curves shown are those of an arbitrarily chosen sand and sandy gravel.

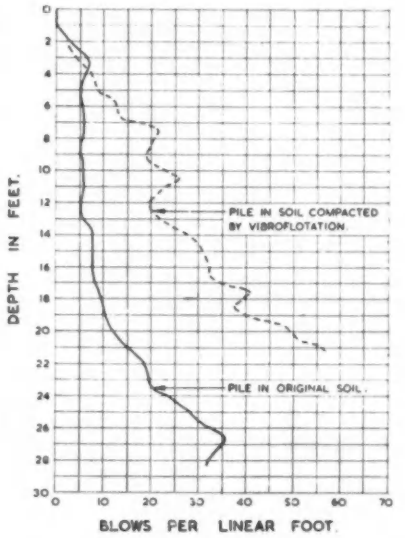


Fig. 3. Pile Driving Resistance Test conducted by Parsons, Brinckerhoff, Hall and McDonald, Consulting Engineers, New York.

(2) The process is less costly in materials than alternative methods of achieving the same results.

(3) By the compaction the bearing capacity of the soil is increased; therefore, foundations can be smaller and piles can often be eliminated or their number and length greatly reduced.

Furthermore, certain types of fill cannot be compacted at depth by any other means.

The process is most effective in granular soil. A minimum thickness of 8-ft. is considered necessary in order to be economical, a depth of 12 to 30-ft. is usual, but 35 to 50-ft. can be achieved.

Vibroflotation may also be used for compaction of concrete and for consolidation of pre-packed aggregates and granular strata, into which grout is injected, and for similar processes using chemical consolidation. The process can also be used effectively under water. It also has a wide range of other uses in addition to its most obvious application to provide foundations for buildings, chimneys or heavy vibrating machinery. Thus it can be used to compact airport runways, parking aprons and highways, earth dams, back filling to dock walls and the like and to provide with injected cement grout stabilised resistance to washout and erosion on coastlines.

A number of full-scale operations on large building sites have been carried out with spectacular success and reports on some of them have been published. In all cases, the safe bearing capacity was increased enormously and settlement under vibratory loads reduced to a minimum.

†On certain occasions sand has been shown to stand vertically for some time in cuttings made through sand strata compacted by the Vibroflotation process.

GRANULAR NON-PLASTIC SOILS—COMPACTNESS BY BURMISTER * (See Ref. below)

Relative Density (%)	0	40	70	90	100
COMPACTNESS	LOOSE	MEDIUM	COMPACT	VERY COMPACT	
Relative Supporting Values : Silt	Poor to Fair	Fair to Good	Good-Very Good	Excellent	
Sand	Fair to Good	Good	Very Good	Excellent	
Gravel	Fair	Good-Very Good	Very Good Plus	Excellent	

* Burmister: "The Importance and Practical Use of Relative Density on Soil Mechanics."

Shiprepairing Facilities for Puerto Cabello.

The construction of a 673-ft.-long drydock, at Puerto Cabello, has been started by the Venezuelan Government as part of a comprehensive shiprepairing establishment designed to provide all necessary maintenance and repair facilities for Venezuelan warships, tankers and dry-cargo vessels. It is estimated that the cost of the entire scheme, which is expected to take three years to complete, will total some $36 mn.

The drydock, and approach channel nearly two miles long, and appropriate workshops and services, are being built first. These will be followed by the construction of shipbuilding facilities and fitting-out berths. When completed, the drydock will accommodate ships of 30,000 tons, and an inner caisson, 207-ft. from the head of the dock, will enable two vessels to be repaired at the same time.

The approach channel leading from Puerto Cabello, 9,186-ft. in length by 328-ft. in width, will have a depth of 49-ft. There will be a circular area of more than 1,200-ft. in diameter for manoeuvring vessels before and after drydocking. Two smaller fitting-out docks will be provided here.

Silt in Bombay Harbour.

Following the abnormal silting in Bombay harbour and its approaches, caused mainly by heavy rains in the 1954 monsoon, a resurvey was made recently by the Indian Navy. This has revealed that the depth of water is 4 to 8-ft. less than expected. The Bombay Port Trust is planning further dredging from the data provided.

The Recent Damage to the Genoa Breakwater

The Effect of Sea Conditions on Vertical Walls

By Dr. AGATINO D'ARRIGO
(Director of the Port of Catania).

ON the 19th February last the Port of Genoa (Fig. 1) was struck by a severe tempest and enormous damage was done to the harbour works and shipping inside. Several large breaches were driven through the massive outside breakwater walls, as shown, and the heavy seas swept into the harbour causing serious sinkings and damage to vessels at the wharves and moorings. The seas within the harbour were a frightening spectacle, and it is a miracle that the whole of the new port was not destroyed entirely.

In the official bulletin of the Port Authority for Genoa Signore Mario Grimaldi, an engineer of the harbour staff published a memorandum under the heading "Why has the breakwater failed?" In this he offers several frank and forcible comments and concludes, "the grave calamity was due to two causes which in combination caused the damage to the walls; they are the exceptional meteorological conditions and the past inadequacy of knowledge and technique of maritime construction."

As regards the meteorological conditions, these are confined to south-west gales. The position of Genoa in this respect has been well defined in the "Giornale del Genio Civile" (Italian journal of Civil Engineering) by the expert maritime engineer Oddone Bernardini in reference to the great gale from the south-west on November 27, 1898.

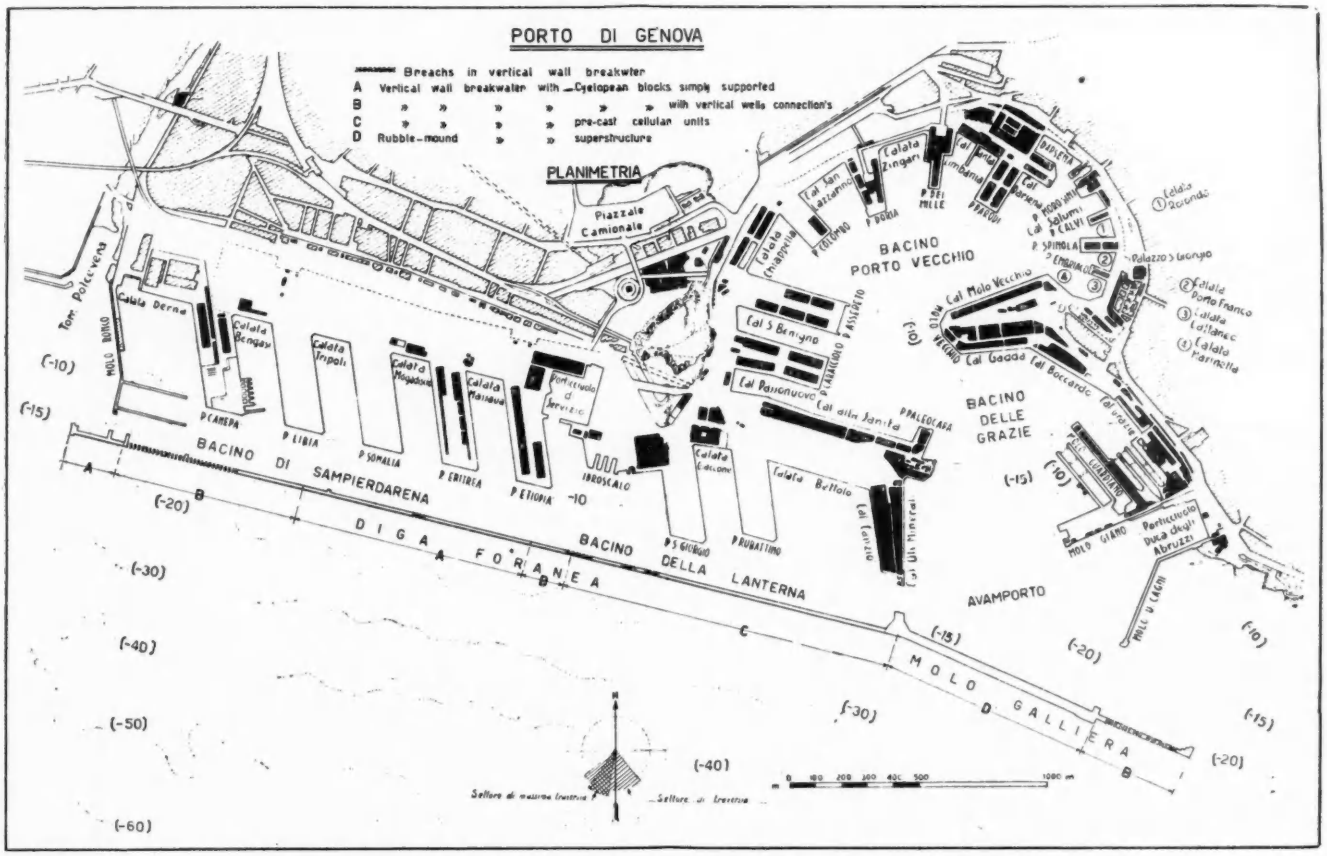
"The Port of Genoa, situated on an open coast at the head of a large gulf has a wide sea of great depth immediately to its front and is therefore subjected to violent sea assaults. The sector of maximum fetch, and at the same time the direction from which come the strongest winds and heaviest seas, is bounded by the east coast of Minorca and the west coast of Sardinia and extends to the Algerian coast. This sector of an amplitude of 30 degrees is contained in the first boundary of the third quadrant. From this there arises the tradition of Italian sailors that a south west gale in this sector arrives at Genoa as a south-south-west gale.

"The greatest stretch of open sea to the front of Genoa, or rather the greatest distance, from land to land, over which waves can be generated ('fetch') is about 600 sea miles. Over this long traverse of deep water the waves pushed by the dominant wind are free of obstruction and therefore can increase considerably in height, amplitude, and velocity. Fortunately it has been rare at Genoa that the seas of the south-west gales have been accompanied by a strong wind in the same direction, more frequently the seas have been 'old seas' or rather the swell resulting from an abated wind in other parts of the Mediterranean."

Bernardini stated that on November 26, 1898 the wind had increased to over 60 kilometres/hr. and waves "little inferior to 7.0 m. high," although he does not neglect to add that he had observed waves of a maximum height of 10.0 m., in accordance with the well-known formula of Stevenson.

$$h = 0.467\sqrt{d}$$

where d = maximum length of fetch in the direction of the wind in sea miles (500)
h = wave height


PORTO DI GENOVA
Breachs in vertical wall breakwter
A Vertical wall breakwater with Cyclopean blocks simply supported
B » » » » » » with vertical wells connection's
C » » » » pre-cast cellular units
D Rubble-mound » » superstructure
PLANIMETRIA
Piazzale Camionale
BACINO PORTO VECCHIO
BACINO DELLE GRAZIE
BACINO DI SAMPIERDARENA
DIGA FORANEA
BACINO DELLA LANTERNA
AVAMPORTO
MOLO GALLIERA
MOLO VECCHIO
MOLO GIANO
Calata Bengasi
Calata Tripoli
Calata Magdalena
Calata Marsala
Calata Derna
Calata Zingari
Calata Chiappella
Cal S Benigno
Cal Ponticello
Cal Gaggia
Cal Boccardo
Cal Lanterna
Cal Un Minerali
Ponticello di Servizio
Ponte Porta Pila
Ponte Porta Siberia
Ponte Porta Principe
Ponte Porta Soprana
Ponte Porta Romana
Ponte Porta Nuova
Ponte Porta Vacca
Ponte Porta Reale
Ponte Porta Colonna

Recent Damage to the Genoa Breakwater—continued

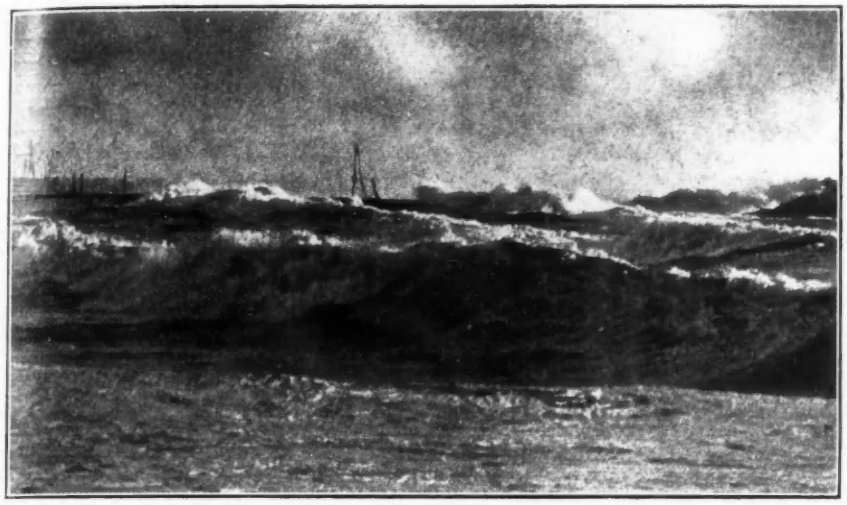


Fig. 2. Sampierdarena Basin, after the destruction of 450 m. of breakwater, when the seas swept over the harbour causing grave damage to wharves, plant and shipping.

He computed the maximum pressure of the breakers to be equal to 30.9 tons per square metre, and also computed at 48.9 tons per square metre the pressure which caused the shear of a metal mooring bollard, firmly secured to the concrete of the breakwater, which was sheared off from its base. In this connection it is interesting and instructive to recall that when the great Leonardo da Vinci on March 17, 1498 was ducal engineer to Lodovico il Moro, he examined at Genoa the grave damage done to the Old Mole of the then harbour by a tempest in February of the same year. The superstructure of the wall was demolished and Leonardo noted that the violence of the waves had wire-drawn (stretched) parts of the iron members (Codice Atlantico folio 4).

In the recent gale, February 19, 1955, "the waves were higher than 7.0 m. pressed by a S.W. wind of 120 km./hr. on the first afternoon. The breakers beat against the outer face of the breakwaters with a frequency of 12 seconds, their impact was 30 tons per square metre."

It is important, in any enquiry into the causes of the disaster at Genoa, not to neglect any natural cause which may have contributed to the total conditions.

It is evident that there was insufficient knowledge either of the local physiography or of the technique of maritime port works, in spite of the good examples set by the ancient Romans. This neglect of past experience has been openly denounced since 1932, that is to say before the destruction of a similar structure, of which the present writer was an eye-witness. This was the disaster to the vertical wall breakwater at Catania, Sicily on March 26, 1933. Six months earlier the writer in collaboration with the late Giovanni Penna, a celebrated Italian maritime engineer and contractor, published a paper on vertical wall breakwaters in which doubts were expressed regarding the suitability of this type of construction for certain situations, in particular those of Catania, Genoa, and Algiers. These carefully weighed words of warning were again repeated at the International Conference of Maritime Meteorology at Genoa, 1951, and yet again at the XVIIIth International Congress of Navigation held at Rome, September 1953, and yet again at the Fifth International Congress of Coastal Engineering held at Grenoble, September 1954.

The engineer Mario Grimaldi records justly in reference to the recent disaster "The supporters of the vertical wall type of breakwater nold that works of this character should be able to provoke wave reflection without shock, while preventing occurrence of the wave-break and the transport that experience has shown to be inevitable on the sloping faces of rubble mound walls."

The many tragic disasters which have occurred with the vertical wall type should, at least, be sharp reminders to the maritime profession that the free reflection of waves from the vertical face is a delicate experiment in nature not devoid of peril. One must need call attention to the fact that no modern treatise of Maritime Construction has yet considered in relation to the vertical wall type of breakwater the possibility of the occurrence of a geohydrological wave break. By this we mean a break caused not only by shallowness but also by the rupture of the orbital motion of the waves caused by the interference of marine currents, or of submarine springs of fresh water.

In 1726, Antonio Vallisneri and in 1783 Lazzaro Spallanzani had observed that the submarine springs of Cadimare, in the Gulf of Spezia, in depths of 11 m. caused an upward current of fresh water which interfered with and deformed the waves of the surface. In 1906 the Italian Ministry of Agriculture published details of a similar phenomenon in the Gulf of Policastio. It occurred in front of the village of Villamare at about 1 kilometre from the shore. There were two circles of water with an almost tranquil surface in the midst of an agitated sea. When the sea was calm they showed as though gently boiling with a circular propagation. This phenomenon is best seen from a height on land or on a vessel. The water depth is 19 to 21 metres and near

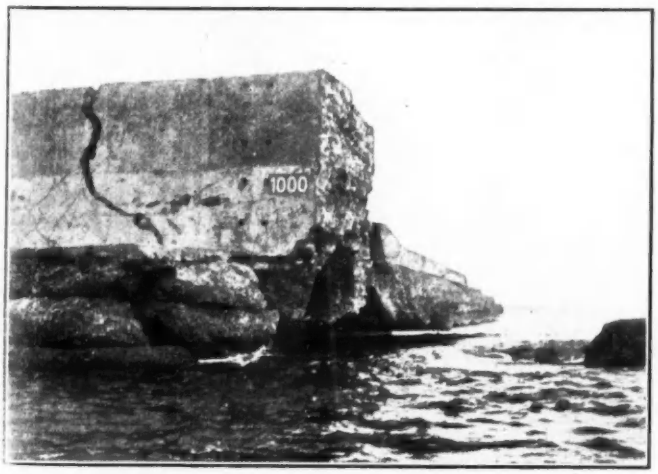


Fig. 3. Breach in vertical wall breakwater of pre-cast cellular units, where the in situ superstructure has been sheared and undercut.

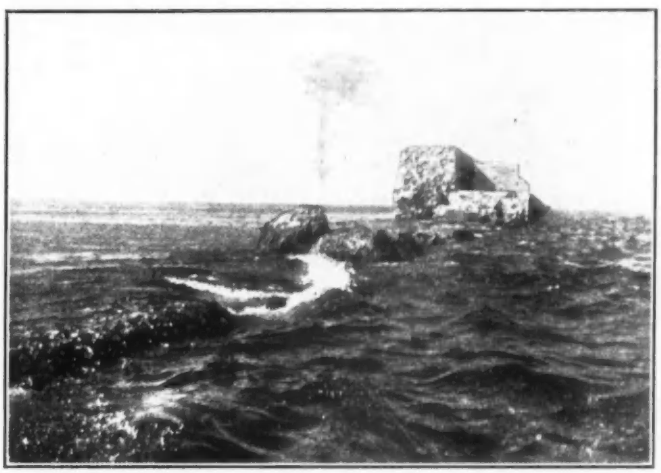


Fig. 4. Breach in wall, looking west of the Sampierdarena Basin—again one notes that the superstructure has failed.

Recent Damage to the Genoa Breakwater—continued

the periphery in a small boat one is made aware of the vortical action by the water impinging on the hull.

The locals call these stilling currents "volli" or boiling water. In Sicily similar spots are termed " vugghi " with the same meaning—that at Donnalucata lies in 5 metres of water.

Similar observations were made in 1785 in 12 metres depth at Torre d Albidona, in Calabria; at Catania; and at Cape Molini in Sicily, as stated in a paper before the fifth International Congress of Coastal Engineering.

In these cases, the continuous and uni directional disturbing current interferes with the orbital motion of the liquid particles forming the wave with an analogous effect to that which takes place when a wave passes into water of a depth approaching its own amplitude and provokes a morphological break.

It is recalled that in 1907 an American engineer Phillip Brasher propounded what he termed a " breakwater of compressed air " which he described as a linear series of ejecting nozzles emitting compressed air upwards from the sea-bed, a device which provoked the " pneumological " break of the surface wave motion.

On page 115 of the official Bulletin of the Port of Genoa for February, 1955, there is a communication from Mr. Giacomo Lombardi of Genoa, who says " In the stretch of the sea (fronting Sampierdarena) within 420 lineal metres from the damaged breakwater wall there exists a terrific submarine current of which only too well we have seen the effect. The locality was in a state of " zeneize " (ginger beer) surrounded by froth, that is to say the sea foamed and boiled. Nothing has ever lasted in that area of sea. The Ansaldo (Italian Naval Dockyard) used to test the guns of the Fleet on that spot and the defence wall was always in a state of disrepair from the sea assaults and required reconstruction and reinforcement every year. The walls in each successive Spring of the year were reduced to rubble and scrap iron.

The area of which Lombardi speaks is situated precisely to seaward of the mouth of the Torrent of Polcevera which is, in effect, a submerged valley, or in the modern usage a submarine canyon. This had already been noted by Arturo Issel in the year 1886. Even before Issel in 1846 Lorenzo Pareto made his first bathymetric survey of the Sardo State, then finally under the direction of the Albini he discovered that in the marine depths of the Gulf of Genoa there were clearly defined submerged valleys in continuation of those on land. The " thalweg " of the submerged valley coincides with the prolongation of that of the Valley of the torrent Polcevera over the littoral platform.

We have referred above to the nature of the underground river Amenano at Catania and the vagaries of its discharge; similarly the Polcevera which enters the sea almost alongside the western breakwater, Molo Ronco, of Genoa runs almost dry during the summer but is subject to sudden torrential floods. Consequent on heavy rainfall in the mountains inland it is possible that the rising torrential discharge re-activates the sub-marine springs in the sub channel of the foreshore. This will tend to provoke the destruction of the orbital motion of the waves and cause premature breaking. That the break took place in over 20 metres depth of water and caused vertical jets of green water to the terrific height of over 400-ft. is undeniable—a consequence so different to that which should obtain with theoretical wave reflection.

This shows how necessary it is, in projecting the vertical wall type of breakwater to place the works beyond the hazards of breaking waves not only as regards depth of water but also clear of any current, salt or fresh, that may interfere with the orbital wave motion and cause geohydrological breaks.

It is permissible to recall that the problems of the vertical wall breakwaters of Genoa, Algiers and Catania are similar but not the same, yet there are certain known factors that are profitable to examine. All three have suffered tragic failures maybe from scarcity of sufficient information. For example, in the waters of the sea facing Catania the fishermen of shell-fish speak of innumerable springs of fresh water which rise from the sandy bottom. In the harbour these springs have been related to the famous river Amenano which is now subterranean. The vertical breakwater of Catania was completely destroyed on March 26th, 1933, and its destruction was not only visually observed but cinematographed, which recorded the breakers accompanied by high vertical jets.

Grimaldi's account of the damage at Genoa in February, 1955, has this to say. " . . . meanwhile in the field more wide of matured experience in other ports of Italy and abroad some alarm was expressed but on the other hand justified regarding the investigations of disasters that had already taken place elsewhere: especially those of Catania (1933) and Algiers (1934). But it was said then and has been repeated since, that they were caused by gales of very exceptional violence (for Catania it was called ' maremoto '—seaquake) in places more exposed than Genoa." Now, in fact, no earthquake or seaquake took place as has been verified, at the times, by the local seismological observatories. There is not the slightest doubt that at Catania it was a severe gale alone; from E.N.E. and not from the maximum fetch, actually the fetch was 252 sea miles, the wave height 7.50 m., length 230 m. and period 12 seconds and breakers occurring in 18 m. depth of water. The old mole of rubble mound type, that is with inclined apron, was better adapted to spend and absorb the energy of the break, moreover it withstood the actual trial which was by contrast catastrophic for the vertical wall.

In conclusion, the writer holds that, for the future security of the Genoa breakwater, a more complete survey should be made of the port zone, the littoral platform, and, in particular, the submerged valleys of the Polcevera, Bisagno and Entella. From the nature and sequence of the destructive action it seems indispensable, indeed urgently necessary, that a more efficient and a more modern approach to the consideration of all technical matters affecting the security of the maritime works must govern future reconstruction.

Book Reviews

" Steel Designers' Manual " by C. S. Gray, B.Sc. (Eng.), A.M.I.C.E., A.M.I.Struct.E., L. E. Kent, B.Sc. (Eng.), M.I.C.E., M.I.Struct.E., W. A. Mitchell, M.I.Struct.E., M.I.W., and G. B. Godfrey, A.M.I.C.E., A.M.I.Struct.E., A.M.I.Mun.E., Published by Crosby Lockwood & Son Ltd., Price 50s. net.

This Manual on Steel Design has been written and compiled by the authors as a result of a number of professional and educational requests for a work to bridge the gap between the normal textbook on the theory of design and its practical application in constructional engineering.

The book is intended to embody in one publication all material necessary for the design of steel framed structures. It is emphasised that this is not a normal textbook dealing with the theory of structures but a comprehensive compilation of data including much hitherto unpublished material, particularly in relation to the analysis and design of rigid frames.

A special committee composed of representatives of the British Steel Producers' Conference and the British Constructional Steelwork Association was formed to obtain the opinions of practical designers regarding the material to be included in the work. The contents include sections dealing with the theory, design and deflection of beams of all kinds; forces and deflections in framed structures; modern methods of structural analysis; theory and deflection of rigid frames, including 67 specially computed charts giving information on single storey rigid frames; bunkers and hoppers; beams in torsion, welded work. The theoretical section contains many worked examples to amplify the text.

The book is illustrated with numerous line diagrams of a very high standard. There are also sections dealing with the details of practical design, including tension and compression members; foundations, brackets, plate girders (riveted and welded), glazing, sheeting and flooring details; properties of sections.

" Ports of the World," published by the Shipping World, Ltd., London, price 80s., post free.

This edition (the ninth since the book was first compiled) gives details of port accommodation, facilities, charges, repairs, pilotage, tonnage bunkers, officials, etc. A new feature, however, is the replacement of the general world maps by a series of line drawings showing the layout of certain oversea ports. All sections have been brought up to date; some United Kingdom harbours now regarded as redundant have been withdrawn; there is new information on Japan; and the Irish ports have been separated from the U.K. and moved to the European section.

Model Tests with Pneumatic Breakwaters

Recent Experiments Carried Out in Germany*

By PROFESSOR WALTER HENSEN, Dr.-Ing.

I. OCCASION AND PURPOSE OF THE MODEL TESTS

In 1952, Laurie [13, 14] published a brief article on the construction of a pneumatic breakwater designed to protect the lock of the railway ferry Dover-Dunkerque, in Dover Harbour, against stormy seas.

This gave rise to the idea to consider the use of a pneumatic breakwater to calm the sea in Heligoland harbour, and to examine the effect of such a breakwater by means of model tests. In the event of positive results, the pneumatic breakwater might represent an economic solution of the problem of wave reduction, a solution which would have the advantage of being removable, and which would not constitute a hindrance to shipping.

At a meeting between representatives of the waterways and shipping authorities and the Franzius Institute, which took place at Hanover on March 29th, 1954, a programme for tests with a pneumatic breakwater was discussed, and further experiments with several consecutive compressed air pipes were decided upon. In the course of a further discussion at Hanover on June 10th, 1954, further tests were agreed upon in principle with a view to ascertaining the internal motion phenomena of the wave as it passes through the pneumatic breakwater, so as to obtain a greater knowledge of the effect of the pneumatic breakwater. If possible, the disturbed orbital motion was to be filmed.

The tests with the pneumatic breakwater were designed to clarify the following questions:—

(1) Is it possible to obtain, by means of the pneumatic breakwater, an effective wave reduction?

(2) Which arrangement of the pneumatic breakwater combines the least capital cost with an optimum effect?

(3) How does the pneumatic breakwater affect the internal motion phenomena of a wave passing through it?

(4) Clarification of the way in which the pneumatic breakwater works.

(5) Collection and appraisal of all available literature on pneumatic breakwaters.

II. TEST MODEL

(a) Scale of the Model and Consideration of Similitude.

According to Froude's Law of Similitude, it is possible to apply the results of wave tests on models to natural conditions. Such scale transformation is not necessarily permissible in the case of the pneumatic breakwater, since it is necessary to take into account not only the forces of gravity and inertia, but also the peculiarities of the water/air mixture. Neither the specific weights of the water/air mixture nor the size and distribution of the air bubbles, at the model and under natural conditions, are in any fixed and known relationship to each other, so that the model experiments cannot provide conclusive information about the quantities of air required for the reduction of waves under natural conditions. Schijf [18], in his model experiments, has expressed the relationships between the quantity of air required for wave reduction and the length and height of the waves by means of a dimension-less term and has, in this way, calculated the quantities of air which would be required under natural conditions. He thereby arrives at very large quantities of air which are several hundred times greater than the quantities of air actually found to be required in several known cases of actual practice. The scale transformation from model scale to natural scale is subject to a coefficient which is independent of the scale, and which is completely unknown and cannot be derived from the model experiments hitherto carried out.

(b) Testing Arrangement.

The tests concerning the reduction of waves by means of the pneumatic breakwater were carried out in the large towing basin of the Franzius Institute. The basin has a width of 2.20 metres and a utilizable length of 112 metres. During the trials, the depth of water varied between 1.15 and 1.17 metres.

At one end of the basin, a variable wave machine was installed. The waves investigated had a length varying between 1.8 and 7.6 metres and a height varying between 0.15 and 0.28 metres. A wave filter was installed at a distance of 7 metres from the wave machine. The pneumatic breakwater was installed at a distance of 32 metres from the wave machine. Having passed the pneumatic breakwater, the waves ran on another 80 metres to the other end of the testing basin, where they were reflected. The individual tests were only carried out as long as there was no disturbance by reflected waves.

The pneumatic breakwater consisted of steel pipes of 2.5 centimetres bore, which were laid transversely across the bottom of the testing basin. The pipes were fitted with nozzles of 1.2 mm. diameter spaced at intervals of 15 cm., serving as outlets for the compressed air which was ejected upwards into the water. The number of pipes used for the tests varied from 1 to 5, and their distance could also be varied. The compressed air was supplied by a compressor feeding an air tank, to which the hoses leading to the pipes were connected.

The tests designed to clarify the internal motion phenomena of the waves and the effect on them of the pneumatic breakwater were carried out in a small glass basin where the conditions for observing these phenomena were particularly favourable. The small glass basin had a length of 8.60 metres, a height of 0.70 metres and a width of 0.13 metres. A wave absorber was fitted at one end of the tank. A mercury manometer permanently connected to the pressure line permitted the exact measurement and control of the pressure during the tests.

III. THE TESTS

(a) Measuring the Waves and the Internal Motion Phenomena in the Large and Small Basins.

The basin was filled up to the desired water level, and the pneumatic breakwater set in motion and adjusted for the desired air pressure, whereupon the wave machine was started.

In order to determine the wave reduction caused by the pneumatic breakwater, the waves were measured in front of, and behind, the pneumatic breakwater. The measurements were taken in such a way that it was possible to compare comparable waves. The measurements were carried out by different means, using electric and photographic devices in the large testing basin, but only photographic devices in the small glass basin.

As it was found, during the tests, that the waves attenuated by the pneumatic breakwater were reforming some distance behind it, the progress of the waves was, with the later tests, photographed over a greater range of the testing basin. Two synchronized cameras were used for films as well as lengthy sequences of individual photographs. The height of the waves could be measured with an accuracy of about 0.5 cm. (according to either method), whilst the wave length could be measured with an accuracy of 2 cm., using the photographic method.

The speed of the waves was determined by two methods with an accuracy of 0.1 to 0.05 seconds. The wave frequencies were determined by the stop watch (accuracy 0.1 seconds) as well as

* Condensed from the German, "Proceedings of the Franzius Institute," Vol. 7, Hanover Technical College, March, 1955. (The tests were carried out by Dr. Otto Linke.)

Model Tests with Pneumatic Breakwaters—continued

from the oscillographs and film exposures (accuracy 0.05 seconds).

The attenuation (D) caused by the pneumatic breakwater is given in per cent. of the height of the original wave:—

$$D = \frac{(H_1 - H_2)\ 100}{H^1} \text{ per cent.}$$

where H_1 = original wave

H_2 = attenuated wave behind the pneumatic breakwater.

During the tests, it was repeatedly possible to observe wave displacements caused by irregularities in the air escape from the pneumatic breakwater. In such cases, the attenuation effect was no longer uniform over the whole cross-section of the basin so that, with effective attenuation, the waves began to break on one side only. Whenever such phenomena were encountered, the test was repeated after the water had calmed down. However, when these phenomena were small in scale, it was not always possible to discern them, though they sometimes resulted in negative attenuation values of up to minus 18 per cent. It is therefore hardly possible to assign a greater accuracy than plus/minus 5 per cent. to the attenuation values listed in the test reports.

In the small glass basin, the waves were recorded photographically by means of a scale with a square mesh of 5 cm. side length fitted to the glass plates, using partly films and partly sequences of individual photographs.

The water motion caused by the pneumatic breakwater itself, i.e., without the propagation of waves, was determined from the spreading of a concentrated potassium permanganate solution which was carefully introduced as a layer of 3 to 4 cm. thickness on the bottom of the basin on either side of the pneumatic breakwater. As soon as the pneumatic breakwater was set in motion, the air bubbles continuously entrained some coloured solution. In this way it was possible to follow the complete process of water motion, especially when the process was observed on a brightly illuminated background.

The internal motion phenomena of the waves, as well as the motion phenomena caused by the pneumatic breakwater, with and without wave propagation, were made visible by means of particles in suspension which were introduced into the water during the test. After trying a number of alternatives, it was found that the most practicable method was to make use of particles of untreated polystyrene.

For demonstration purposes, a time-lapse motion camera was used to shoot a 16 mm. film at a rate of 64 pictures per second, producing a sufficiently slow picture of the speed of the particles even at the points of highest speeds, so that the movements of the particles can be comfortably followed with the eye.

(b) Measuring the Air Pressure and Volume.

The tests in the large basin were carried out for a limited number of different air pressures, without altering the depth of water, the size of the nozzles, or the number of nozzles per pressure pipe. It was therefore sufficient to determine the air consumption per pressure pipe for the three standard pressures of 2, 4 and 6 kgs. per sq. cm. With the tests in the small glass basin, the pneumatic breakwater used was likewise the same throughout. The requisite air quantities were determined for three different depths of water (20, 30 and 50 cm.) at the following pressures: 1.07, 1.15, 1.30, 2.0 and 3.0 kgs. per sq. cm.

The air quantity was determined volumetrically by measuring the time required to fill with air a water-filled measuring glass placed on top of the nozzles. A more exact measuring of the air consumption was considered unnecessary in view of the impractibility of scale transformation.

IV. RESULTS OF THE TESTS

(a) Wave Reduction Tests in the Large Testing Basin.

1.—General. The large testing basin was used for a great number of test series to ascertain the attenuating and annihilating effect of the pneumatic breakwater. The forms of the waves and the spacing of the pressure pipes of the pneumatic breakwater were varied. The length of the waves varied between 1.8 and 7.6 metres, their height between 0.15 and 0.28 metres. The pneumatic breakwater was used with one, three and five pipes. When more than one pipe was used, the spacing was varied to be 0.2, 1.0, 2.0 and 3.0 metres. The air pressure was varied to be 3, 4 to 4.5, and 5 to 6 kgs. per sq. cm. To characterise the waves used during these tests, the wave "steepness" (ratio of length and height, i.e. L/H) is a useful index, since it was already found after a few tests that the effect of the pneumatic breakwater is dependent not so much on the absolute height of the wave, but rather on their steepness. With the waves used for these tests, the steepness varied between 6 and 77.

The air consumption of the pneumatic breakwater under different operating conditions varies from 0.62—1.5 m³/min. per pipe (=3.0—7.3 cu. ft./ft./min. per pipe). This consumption is fairly high, being of about the same order of magnitude as the air required in actual practice for the annihilation of waves of 1.2 to 4.5 metres height. But, as has been explained in Section II (a), it is not possible to translate the scale from the model to natural conditions, as far as the quantities of air are concerned.

(For reasons of space, the full tables of results are not given in this condensed account; they are, however, summarised in graphs, in which steepness is a parameter in Fig. 1, which has been copied from the German.)

It will be seen from Fig. 1 that, for equal test conditions, the attenuation values show a wide scatter. This scatter, which is

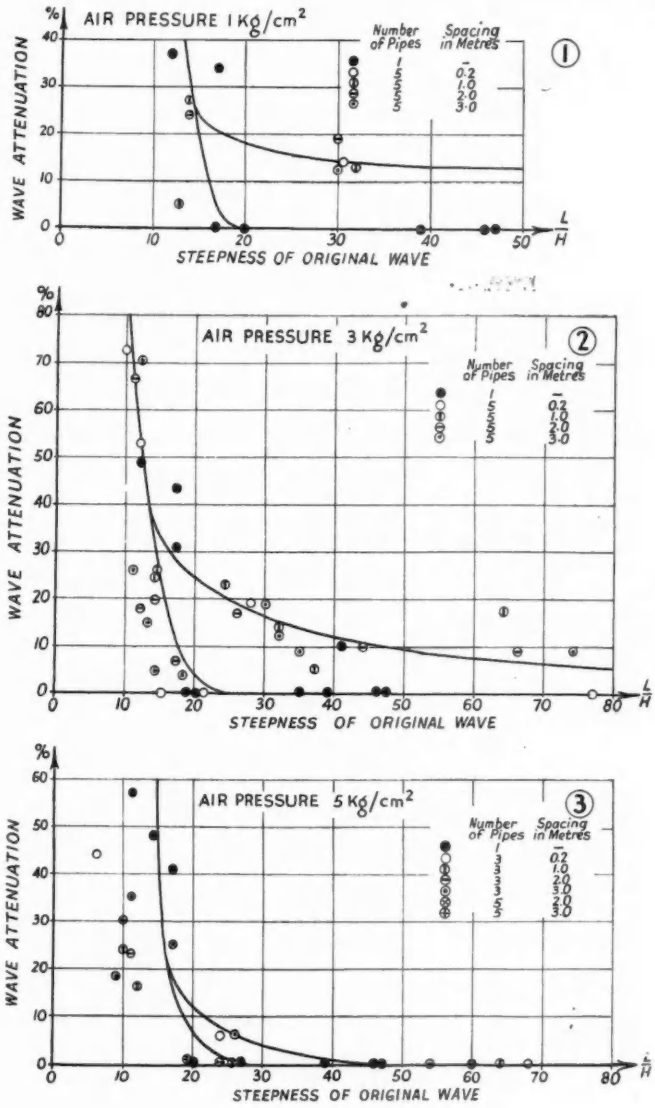


Fig. 1.

Model Tests with Pneumatic Breakwaters— continued

particularly marked with steep waves, is due to irregularities in the surf formation. A contributory reason is that the waves are partly re-forming after having passed the pneumatic breakwater. At a given point, the height of the waves thus re-formed varies with the time. Because of the wide scatter of the results, the attenuation curves plotted in Fig. 1 can only be regarded as rough approximations.

2.—Test Results. The tests showed that it was possible to obtain with the pneumatic breakwater a fairly good attenuation of the waves up to 73 per cent. of the height of the original wave. The attenuating effect was confined to steep waves with an L/H ratio below 15 to 20. The attenuation of steep waves varied between 10 and 73 per cent. and was caused by the fact that the attacking waves formed a more or less complete surf before reaching the breakwater. Flatter waves with an L/H ratio above 20 were not, or not markedly, reduced by the pneumatic breakwater. The tests with flatter waves showed attenuation values which, even in the most favourable cases, remained considerably below 20 per cent. The effect of the pneumatic breakwater was only insignificantly improved by increasing the air pressure, and thus the quantity of air. With steep waves, a doubling of the quantity of air caused the attenuation value to increase by 20 per cent. With flatter waves, with an L/H ratio above 20, an increase in the air pressure does not cause any noticeable improvement in the attenuation effect.

Even an increase in the number of pressure pipes did not lead to any considerable improvement in the attenuating effect of the pneumatic breakwater, except in the case of steep waves with an L/H ratio below 20. The tests were not numerous enough to show reliably to what extent the spacing of the pressure pipes may have an influence on the attenuation.

With the tests in the large testing basin, the attenuating effect of the pneumatic breakwater could sometimes only be observed in the immediate vicinity of the breakwater. Behind the breakwater, the waves gradually re-formed to resume their former height. But it was by no means always the case that the height of the wave re-increased with the distance from the breakwater. It was frequently observed that the regain in the height of the wave was subject to continuous changes in space and time. As it was not possible to extend the tests over long enough periods because of the wave reflection in the testing basin, it was not possible to determine to what extent these changes in the height of the waves were subject to periodicity.

These observation of occasional regains of the former wave height behind the pneumatic breakwater seem to indicate that the waves passing through the pneumatic breakwater were obviously not always annihilated, but that they were merely transformed, and that this transformation was reversed after the waves had passed the pneumatic breakwater. But this applies only to those waves which have not, or have hardly, been brought to form surf when passing over the pneumatic breakwater. But where the pneumatic breakwater caused the waves to form strong surf, these waves were annihilated by the surf, and passed on as a surge of much smaller height than that of the original wave, obviously depending on the extent of the surf.

The irregularities, in space and time, of the reformation of the waves, partly or wholly to their former height, also explain the pronounced scatter of the test results. Moreover, with the steep waves, the extent of surf formation was not always the same, a fact which was reflected in correspondingly different values of attenuation.

(b) Tests in the Small Glass Basin.

1.—General. The tests in the large testing basin had shown that an annihilation of waves by means of the pneumatic breakwater is possible. But they had also shown that, in many cases, the waves are merely temporarily attenuated, that the annihilating effect is confined to steep waves with an L/H ratio of about 15 to 20, and that, from this degree of steepness, the effect of the pneumatic breakwater on flatter waves ceases fairly abruptly. The tests under natural conditions, discussed in the available literature, were partly successful, partly not, without there being any obvious reasons for such differences. In order to eliminate these uncertainties still affecting the pneumatic breakwater, it was desirable to obtain a clear picture of the way in which the pneumatic breakwater works.

2.—The Water Motion Generated by the Pneumatic Breakwater. The compressed air emerging from the pressure pipes rises to the water surface in the form of finely distributed bubbles. This causes an upwards current of water and, in consequence, the formation of vortices on either side of the pressure pipe.

Near the surface, the water current moves away from the pneumatic breakwater; near the bottom, the water flows back towards the breakwater. If the water is deep and the current strong, the primary vortex is accompanied by secondary vortices. On the exposed side of the pneumatic breakwater, the current opposes the attacking waves. On the lee side, the current flows in the same direction as the wave. The vortex on the exposed side therefore causes the waves to mount and, if they are steep enough (L/H ratio smaller than 20), to form surf, whilst the lee side vortex tends to flatten the waves.

The air current rising in the water supplies the energy for the vortices.

(Here follows an account of the known laws governing the rate of ascent of bubbles of varying diameter.)

The efficiency of the pneumatic breakwater is governed by the generation of a vertically rising water current of the greatest possible strength. The result is mainly governed by the total quantity of air used, whilst the size of the bubbles is of only secondary importance.

(An account is given of experiments to determine the size and velocity of vortices produced by different air volumes at varying depths.)

It is clearly shown that there is initially a rapid increase in the size of the vortices as the air pressure increases. For each given depth of water, however, there is an upper limit of air pressure, beyond which there is no further appreciable increase in the size of the vortices. As the depth of water increases, an increase in the air pressure has a greater effect. As the air pressure increases the deviation of the curves from each other becomes the greater, the deeper the water; this corroborates the earlier statement regarding the greater influence of the depth of water on the pneumatic breakwater.

3.—Shape and Orbital Motion of the Waves Examined. The waves used for the tests in the small glass basin had a length of 140 cm. and a height of 12 cm., so that their L/H ratio (" steepness ") was 12. The waves had a completely uniform run through the basin and were completely annihilated on the ballast filling at the other end, so that the tests were not affected by any disturbing influences of reflected waves. During the passage of the waves, the orbital motion of the particles was almost circular.

The effect of the pneumatic breakwater on the internal motion phenomena of the waves was investigated for a depth of water of 50 cm. and for air pressures varying from 1.07 to 3.0 kgs. per sq. cm. The results can be summarised as follows.

4.—How the Pneumatic Breakwater Works. On the basis of the tests carried out so far, the way in which the pneumatic breakwater works can be roughly described as follows:

The rising air bubbles of the pneumatic breakwater entrain water upwards. On reaching the surface, the rising current of water flows off on either side of the pneumatic breakwater. The loss of water is compensated by in-flows at the bottom, so that vortices are formed on either side of the pneumatic breakwater. On the attacking side, the waves run up against the surface flow of the vortex and " mount ". If the vortex speed is high enough and the wave steep enough, surf is formed. This happens at a distance corresponding to between 3/5 and 4/5th of the length of the vortex in front of the pneumatic breakwater. The air current as such, rising from the pressure pipe, has no measurable influence, under model test conditions, on the wave reduction or surf formation; neither has the elastic water/air mixture present at these points. On the lee side of the pneumatic breakwater, the waves run in the same direction as the surface flow of the vortex and are temporarily stretched and flattened.

It is necessary to distinguish between two types of wave reduction:

(1) Wave reduction through formation of surf on the front-side vortex, i.e., genuine wave reduction which may lead to a complete annihilation of the waves; and

Model Tests with Pneumatic Breakwaters—continued

(2) Wave attenuation on the lee side, i.e., a temporary attenuation which is confined to the area covered by the lee side vortex and permits the wave to resume its former height at the end of the vortex behind the pneumatic breakwater.

The tests have not provided any clear indication of the influence of the propagation speed and periodicity of the waves.

The effect of the pneumatic breakwater on the waves may be likened to the effect on an attacking storm flood of tidal currents at flat coasts and in tidal estuaries, which also cause the waves either to mount or to flatten.

Although the break in the continuity of the water and the compressibility of the water/air mixture has no influence on the degree of wave reduction in the model, it is still possible that such an influence is present on the larger scale of natural conditions. It might be possible to obtain a more effective wave attenuation with lower consumption of compressed air, if the water/air mixture is uniformly distributed over a greater area. In that case, it would be necessary for the air to escape from perforated plates rather than from pressure pipes.

V. CRITICAL EVALUATION OF AVAILABLE LITERATURE

Apart from the tests, all available literature on pneumatic breakwaters has been collected and examined. There are, in fact, more publications on the subject than had been expected. Some of them, however, are little known because they were published in journals which have little to do with hydraulic engineering. As the appended bibliography shows, there are a number of publications, reaching back to 1907, concerned with the practical use as well as model tests of pneumatic breakwaters.

(a) Tests Under Natural Conditions.

The first pneumatic breakwater was constructed in 1907 by the American Brasher[3]. Since then, several pneumatic breakwaters have been constructed, the latest being the one constructed by Laurie[14] in 1952 at the lock of the railway ferry, Dover-Dunkerque.

The data, culled from available publications, on actually constructed pneumatic breakwaters and the experience gathered in regard to their efficiency show that for a precise assessment of the pneumatic breakwater, the information available is rather incomplete, and with the exception of Laurie, a quantitative indication of the reduction effect is not available. The practical tests do, however, show that it was possible to reduce, by means of the pneumatic breakwater, waves of 1.5 to 4.5 metres height if these waves were steep (L/H ratio from 8 to 15), and if the pneumatic breakwater was placed in water of sufficient depth (9 to 12 metres). In contrast, the pneumatic breakwater remained without effect at a depth of 3 metres where it can be assumed that, in the shallow water, the waves at the indicated swell of 5 or 6 had largely been converted to translatory motion. Where the pneumatic breakwater had a good effect, the air consumption varied between 0.3 and 0.9 cubic metres per minute per metre of pressure pipe. The spacing of the nozzles on the pressure pipes varied between 8.8 and 15 centimetres, whilst their diameter varied between 3.0 and 12.5 millimetres. The pipe bore varied between 7.5 and 10.0 centimetres. The experiment at the "Million Dollar Pier" shows that it is possible to reduce a strong ground swell even with small quantities of air (0.03 cubic metres per minute per metre of pressure pipe). It is likely that, in this case, the attacking wave was closely approaching the state of instability.

The most important result to be derived from these publications concerning actually constructed pneumatic breakwaters must be seen in the fact that the air consumption of the effective pneumatic breakwaters was considerably lower than might have been expected on the strength of model tests.

(b) Model Tests.

Model tests have been carried out by Bogolepoff[1], Platzer[17] and Schijf[18]. Bogolepoff's tests were carried out in 2.4 metres depth of water, with waves of 17 to 20 cm. height and an L/H ratio of 7 to 10. The reduction effect varied from 70 to 100 per cent. The results of Bogolepoff's tests agree with the results of the tests carried out at the Franzius Institute. Bogolepoff has not investigated waves of lesser steepness.

Platzer's and Schijf's tests, too, were confined to very steep waves. Their results are only partly in agreement with the results of the tests discussed here. Platzer and Schijf were mainly concerned with the investigation of the requisite quantity of air. They reject the pneumatic breakwater, which they regard as uneconomic because of the high air consumption required. But Schijf has himself expressed misgivings about the validity of translating this experience from test conditions to natural conditions. He expresses the relation of the quantity of air required for the annihilation of the waves, on the one hand, and the height and length of the waves, on the other hand, as a dimensionless term, using the depth of water as a parameter. Schijf then concludes that there is, at the depths of water examined by him (22.2 and 33.3 cm.), no scale influence, and that the height of the waves has no influence on the quantity of air required. For a given depth, the requisite quantity of air is determined by the length of the wave. Waves of different height but equal length require the same quantity of air, although the steep wave is more unstable than the flat wave. According to Schijf, the lesser stability of the steep wave is compensated by its greater energy, which increases with the height of the wave. These results found by Schijf are in good agreement with the ideas on the effect of the pneumatic breakwater, obtained in the course of the research work carried out at the Franzius Institute.

Using the dimension-less factor already referred to, Schijf has attempted, on the basis of his experiments, to calculate the requisite quantity of air under natural conditions, as stated by Brasher[3, 4]. He arrives at the result that the quantities of air required in actual practice represent no more than 1/500th to 1/750th of the theoretical quantities, and concludes that there must be a coefficient dependent on the scale. He has tried to calculate this coefficient from the model tests carried out by Platzer (85 cm. depth of water) and Bogolepoff (2.40 metres depth of water), without, however, arriving at positive results.

VI. CONCLUDING REMARKS

The pneumatic breakwater has attracted little attention although it has been used, from 1907 right up to now, for the reduction of waves at piers, for the calming of water around stranded wrecks and for the calming of harbour basins, and although model tests have been carried out repeatedly. This comparative unpopularity was due to occasional failures in practice and to the negative opinions expressed by Platzer and Schijf on the basis of their scale translations, which are not admissible. Moreover, in the absence of scientific data, earlier ideas on the effect of pneumatic breakwaters were largely founded on supposition. Right up to the present time, the opinion has been expressed repeatedly that the reduction of the waves was due to the elasticity of the water/air mixture. The research work carried out at the Franzius Institute has proved this assumption to be incorrect. The waves are, in fact, annihilated by the vortices on either side of the pneumatic breakwater. The effect of the pneumatic breakwater is thus reduced to the more general problem of the effect on a wave motion of a water current running opposite to the direction of the waves. With the pneumatic breakwater, the air is only of indirect importance inasmuch as its rising sets the vortices in motion. The pneumatic breakwater is economic because use is made of the differences in the density of water and air.

The model tests do not provide an indication of the air consumption required for practical applications of the pneumatic breakwater. With the scale transformations from model to nature carried out so far, the model tests indicated a quantity of air 500 to 750 times greater than that actually required. The quantity of air required at tests under natural conditions for efficient wave reduction varied between 0.3 and 0.9 cubic metres per minute per metre of pressure pipe. The air pressure applied varied between 1.5 and 7.5 kgs. per sq. cm., the nozzle diameter between 3.0 and 12.5 mm., and the spacing of the nozzles between 8.8 and 15 cm.

Within the indicated limits of its effectiveness, the pneumatic breakwater represents at present the most economic solution in all cases where occasional wave reduction is required and where fixed installations must be ruled out, either because they are too expensive or because they are a hindrance to shipping. The pneumatic

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breakwater can be used with success in order to becalm the water near landing piers, building sites, harbour basins and stranded ships.

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South African Ports Improvements.

The General Manager of the South African Railways told representatives of conference lines in Durban recently that improved facilities at Durban and other Union ports would have to be provided for docking coasters, owing to the recent developments of coastal shipping. An investigation would be made at all ports to consider what extra permanent facilities were necessary.

Tank Cleaning on Tyneside.

Mr. B. Eliot Common, chairman of the Tyne Improvement Commission, announced last month that it was estimated that about 180 vessels a year would use the new oil tanker cleaning berth recently completed at North Shields. The first tests at the installation had taken place recently and appeared to have been satisfactory. Other ships were now waiting to clean tanks.

The Tyne Commission is the first port authority in the U.K. to instal a tanker cleaning berth, and it is hoped that as a result additional tanker tonnage will be attracted to the river for repair.

The German Experiments on Pneumatic Breakwaters

By A. H. LAURIE, M.A.
(Director, Pneumatic Breakwaters Ltd.)

Space does not permit of a detailed appraisal of every facet of the very considerable body of material published by the Franzius Institute. The main purpose of this article is to comment on the conclusions which the authors have reached, and to relate these conclusions to certain aspects of wave reduction which are apparent in full scale pneumatic breakwaters and accidentally in nature. As regards the techniques employed in the tank tests it can only be said that these appear to have been beyond reproach, with the single exception that a wave absorber or spending beach was not fitted to the large wave tank. The result was that in some instances an observation on a particular wavelength and height had to be curtailed owing to the arrival of reflected waves at the point of observation or recording of residual wave heights. It is thought that some of the discrepancies and "scatter" of results which were observed may have been due to reflection phenomena occurring to a more or less degree before they became sufficiently obvious to compel the experiment to be curtailed.

The authors conclude that it is only steep waves which can be completely reduced by a pneumatic breakwater. Steepness in this connection is defined as a length/height ratio of not more than 15-20. (The ratio as expressed is more correctly the inverse of steepness, a high number representing a shallow or flat wave. However the German expression will be retained for the sake of brevity.) They further claim that shallow waves, whose L/H ratio is greater than 20 are not annihilated but are temporarily attenuated inside the zone of active currents generated by the pneumatic breakwater.

While we would agree that, in respect of steep waves, it is easier to secure a marked reduction than in the case of shallow waves, we understand that this observation that shallow waves are only temporarily attenuated is not borne out by model experiments recently concluded in the wave tank at the British Transport Commission's Research Station, Docks and Inland Waterways. The results of the latter investigation are expected to be published shortly and will be awaited with great interest. It can meanwhile be said that where a partial reduction of a wave of steepness of say 29 is secured in the latter tank, the effect is not transitory, nor does it appear with time. There would therefore seem to be some feature in the German tank which permits of the recrudescence of wave motion beyond the air/water barrier. On further examination of the testing arrangements it appears that the conditions prevailing during the investigation of shallow waves are prejudicial to the effective operation of the pneumatic breakwater in the following way. A wave of steepness 20, the steepest wave which gave negative results, the wavelength was 3.9 metres while the depth of the tank was 1.17 metres. The amplitude of orbital motion, albeit flattened, at the bottom would be approximately one third of the amplitude at the surface, and without going into too many details, if the effective barrier formed by the pneumatic breakwater extends, as will be shown later, from the surface to barely half the depth, there is in this instance a considerable escape of energy under the barrier. Energy passing under a barrier produces a residual wave at a distance of a wavelength or so from the barrier, whose surface amplitude is calculable (Lochner, Faber and Penney)[1]. Such an escape of energy, added to the tendency of the tank to reflect waves back towards the observation point, does in all probability account for the failure to achieve either substantial or permanent reduction of waves whose length is long in proportion to the depth of the tank.

The above well illustrates one of the pitfalls of wave-tank work on pneumatic breakwaters. The efficacy of the air stream depends largely on the depth of water. Such depth limits the length of waves which can be used without causing a distortion of the amplitude/depth distribution, and indeed it is unsafe in model work to employ a wave whose length is much in excess of twice the depth of water. It may be argued that in situations where it is desired to employ a full scale pneumatic breakwater, the depth is often small in proportion to the wavelengths encountered. How-

German Experiments on Pneumatic Breakwaters—continued

ever, the effectiveness of the air water stream increases markedly with absolute depth, so that there is more opportunity to intercept a larger fraction of wave energy in full scale work than in models.

Modus operandi of the Franzius Institute Model.

The explanation which is put forward in the German paper for the operation of the pneumatic breakwater model is briefly that the currents or vortices generated by the air stream on the side nearest to the oncoming wave cause the wave to "mount" until partial or complete breaking of the wave crest occurs. In this way it is claimed that the wave reduction is secured. The effect is more pronounced with steep waves, than with waves of less steepness. In other words the reduction is obtained by artificially shortening the wave so that the steepness becomes critical, and the wave tends to break.

In order to examine this statement more closely it is necessary to consider for a moment the distribution of energy in a wave. More will be said on this subject below, but for the present it will suffice to say that half of the energy is kinetic, in the particle motion of the water at all depths; the other half is potential, and is exhibited in the differences above and below still water level of the crest and trough respectively.

It will be apparent that if the entire crest were to be displaced into such a position that it filled the trough, there would be a cancelling out of the positive and negative potential energies, resulting in complete annulment at the surface. In practice of course this never happens: a breaking wave in deep water never takes the full form of a "plunging breaker," rather it exhibits a crumbling of the crest itself, and a modicum of water and entrained air slides down the leading slope of the crest. This is the process which is demonstrated to occur in the model.

But supposing that in some manner the entire potential energy of the crest were to be eliminated by the effect of the surface stream produced by the pneumatic breakwater, there would remain half of the total energy of the wave system still at large in the rotating particles plus the potential energy of the trough. This energy would, if otherwise uninterrupted, re-emerge on the lee side of the pneumatic breakwater as a fresh wave of approximately half the original height.

That this does not happen is shown by the fact that in the model wave reductions in excess of 50 per cent. can occur, despite the fact that the potential energy of the trough has not been matched, and cancelled, with that of the crest.

In the writer's view, therefore, the explanation given in the German paper is not acceptable. It should in fairness be said, however, that when a steep wave confronts a pneumatic breakwater, there is an induced instability which leads to partial breaking, and that a fraction, but only a small one of the total energy becomes convered into heat of friction in the zone of the spilling crest. It becomes thus necessary to examine the data further, in order to derive an hypothesis which accords more nearly with observation, both in models and in full scale breakwaters.

Orbital velocity the significant factor?

In what follows we consider the results obtained by the use of a single pressure pipe. The German view that the improvement in performance achieved by the use of multiple pipes is fitful and subject to considerable "scatter" of results is concurred in; an examination of the results obtained with a single pipe and varying air pressures (equivalent to varying power input) simplifies our approach. The reader is referred to Fig. 1 on page 58 of this issue for a comprehensive graph of wave reductions measured against steepness.

The authors conclude that wave reduction of a substantial character can be secured so long as the steepness does not exceed 15-20. Then, at steepnesses in excess of 20 there is quite suddenly a decline in the effectiveness of the pneumatic breakwater.

One is moved to ask—how significant is steepness? It is a non-dimensional quantity, a mere ratio, and it becomes important only in limiting conditions where the steepness facilitates instability at the crest. Is there any other way in which the properties of the waves investigated can be exhibited, in order to clarify the results? In short what is really *happening* at the meeting place of the wave and the breakwater. The present writer suggests that there is only one physical fact which is relevant to this encounter, and that it is the orbital velocity of the particles of water in wave motion. It is therefore in terms of orbital velocity that we propose to consider the German results.

In converting the data to a fresh parameter opportunity has been taken to convert also into British units, and the results for three air volumes are shown in Fig. 1. Russian results have been abstracted from the same paper, and included in the graph.

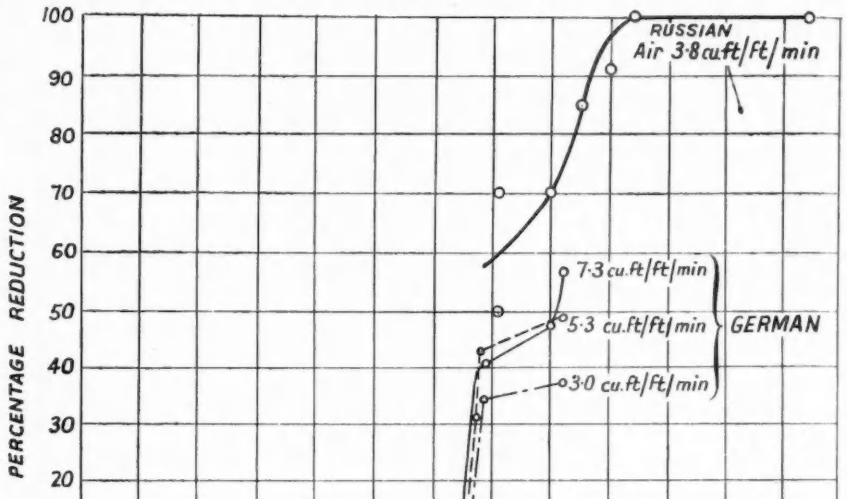

Fig. 1.

It will be seen that "scatter" is largely eliminated. The Russian trials show the greatest reduction, owing no doubt to the fact that the air flow, which is comparable to the lowest German output, was operating more effectively in a deeper tank (7.5 feet as against the German 3.8 feet). Clearly shown is a relation between orbital velocity and percentage reduction, and, most striking of all, there is a complete cessation of effect when the orbital velocity (at the surface) falls below 1.3 ft./sec. It will be seen that an increase in air output, which at the higher orbital velocities results in increased reduction, is of no avail once the limiting orbital velocity has been reached. There are thirteen observations of zero reduction plotted between orbital velocities of 1.36 and 0.67 ft./sec. There is thus a sharp change in the performance of the pneumatic breakwater which can be related to a physical fact in the wave specimens tested.

Corroborative evidence that the absolute orbital velocity is a factor of importance can be found in the following way. Let it be supposed that the effect of the pneumatic breakwater is, in some way which we have not yet specified, tantamount to the interposition of an effective barrier of finite depth, from the surface downwards, and let it be assumed that the wave motion which lies in the zone of the barrier is either reflected or otherwise annulled, leaving the energy resident in the lower layers free to proceed in the direction of propagation and to re-emerge at the surface as a "transmitted wave." Now Lochner, Faber and Penney[1] as mentioned above have shown that the transmitted wave attains a height which is approximately equal to the ampli-

German Experiments on Pneumatic Breakwaters—continued

tude of the orbits at the bottom of the barrier. If therefore the argument is reversed, it is possible to find the depth at which the alleged barrier ceases to be effective, because the amplitude at that depth and the height of the residual or transmitted wave will be equal.

In order to discover the depth of barrier, it is necessary to plot the amplitude distribution curves of waves of different wavelengths as used in the tests. The approximate curves are shown in Fig. 2. There have also been superimposed on the curves the amplitude of the transmitted waves for each of the three air volumes employed. The amplitudes at surface and barrier bottom are then converted into orbital velocities, thus taking wavelength and period into account. Finally by multiplying the orbital velocity at the surface in each case by the percentage amplitude at the indicated depth we arrive at the following result :

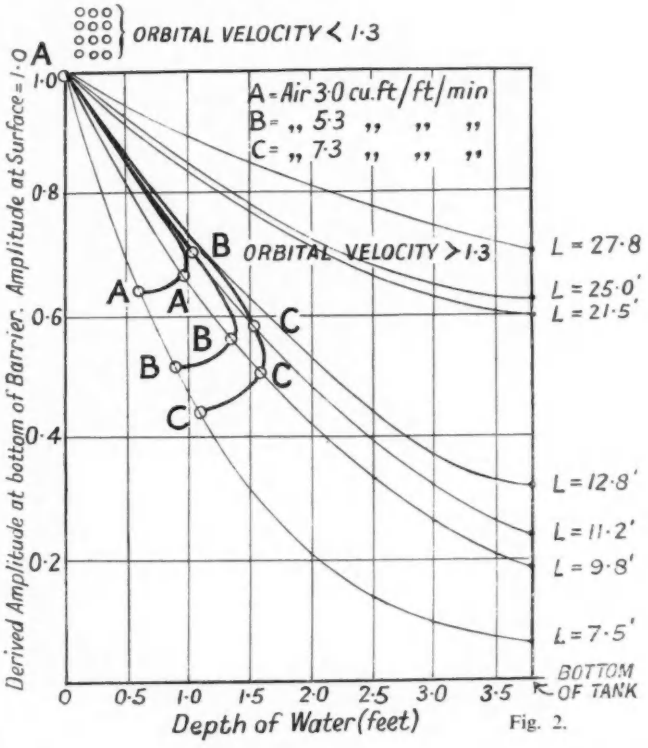

Fig. 2.

1 Air input : cu. ft. /ft./min.	2 Vo at surface ft./sec.	3 Vo fraction at depth ft./sec.	4 Actual orbital velocity at bottom of barrier, ft./sec.
3.0	1.64	0.64	1.05
3.0	1.32	0.66	1.02
5.3	1.64	0.51	0.84
5.3	1.32	0.57	0.87
5.3	1.36	0.68	0.93
7.3	1.8	0.42	0.76
7.3	1.6	0.52	0.84
7.3	1.36	0.6	0.81

It is seen that for each group of air volumes the orbital velocity at the bottom of this effective barrier is approximately constant, and that this velocity is slightly less the higher the volume of air used.

The same process may be applied to the Russian figures, and the result is again fairly constant at a mean orbital velocity at the bottom of the barrier of 0.52 ft./sec. This figure is lower than the German results, but it is impossible to make comparisons, since the conditions (depth and possibly temperature) were different.

Referring for a moment to the possibility that the physical fact of orbital velocity may also prove, without scale correction, to be a determining factor in the construction of full scale pneumatic breakwaters, it may be said at once that limiting velocities of the above order are to be found at the bottom only in the case of very low long swells.

Depth of the Effective Barrier.

The depth to which the barrier operates can also be determined from an examination of Fig. 2. The mean depth of effectiveness for the different air outputs is :

Air output	3 c.f/ft./min.	0.8 feet.
	5.3 ,, ,,	1.1 feet.
	7.3 ,, ,,	1.4 feet.

Compared to the depth of the tank, the effective barrier is small, and it is evident that the air stream does not induce the necessary condition in the water until the bubbles have travelled some distance upwards.

A theory of the operation of the pneumatic breakwater.

Reverting to the idea expressed above that the one physical fact of importance in the clash between the waves and the pneumatic breakwater is, in respect of the waves themselves, the particle velocity (the other material fact being the velocity of water set in motion by the air stream), it appears that for a given set of conditions induced by the air stream, there is a limiting particle velocity below which there is no effective interaction between the two systems. The limiting condition is to be sought at the bottom of the barrier, because if the particle velocity is just sufficient at that depth it will obviously be amply sufficient at other depths between that depth and the surface.

In order to clarify the position a few words must be said concerning the nature of wave motion, and it will be assumed that, in line with modern observation, the properties of the Stokian (irrotational) wave are to be presumed in preference to those of the Gerstner (trochoidal) wave. In the Stokian wave the orbital motion of the individual particle is elliptical; each particle does not quite return to the point from which it started at the beginning of a wave cycle. There is thus a delicately balanced system of particles in harmonic motion, each particle transmitting energy to its neighbour, and obeying the laws of motion for a gravity wave. Half of the total energy of the wave is contained in the kinetic energy of the oscillating particles; the other half is manifest as potential energy in the heights above and below still water level of the crest and trough. While we are for the moment primarily concerned with the kinetic component of energy, it must be emphasised that the potential energy can travel only by virtue of the system of moving particles, and that the two components, kinetic and potential are inextricably locked together.

What happens, then, if the orbital motion is disarranged by a sudden change in velocity of the water mass? One effect is that the orbits are distorted, and the degree to which the orbit is distorted out of resemblance to its original shape depends on the relative velocities.

It is not proposed to embark at this stage on a mathematical treatment of orbital displacement it will suffice to point out that, a priori, the continuity of harmonic motion which is essential to the propagation of a wave is seriously impaired by the action of a water stream generated by the bubbles of a pneumatic breakwater.

The Effect of Discontinuity on Waves.

Summing up so far, the gross result of the action of the induced water currents may be said to be the creation of a change of state in the path of the waves. It is well known that a change of state in a medium can serve as a reflecting surface. In the case of water, this change of state may take various forms from a granite breakwater, at which full clapotis is exhibited by deep water waves, to a change of velocity such as is created by tidal streams, or by the pneumatic breakwater. (Changes of density are also effective, but they do not feature in the present discussion.) The change of state which is most commonly to be seen at full scale is the condition in the wake of a ship. Here one observes that the water in the zone of eddy created by the ship's wake and slipstream from the propellers is calm. On the weather side, assuming waves whose progress is normal to the line of the wake, the sea is in a state of partial clapotis; there are short steep waves to be seen, which are similar in appearance to the standing waves seen off a solid breakwater. The zone of calm water however does not extend for any great distance on the lee side of the wake. The reason for this is believed to be that the wake itself is quite

German Experiments on Pneumatic Breakwaters—continued

shallow, and hence the reflecting barrier formed by it is unable to prevent the re-emergence of transmitted waves whose energy has passed under the barrier. Here then is a primitive, and largely ineffectual breakwater of finite depth, to which reference has been made above and it may be likened to a badly designed pneumatic breakwater so far as its effect goes.

In the Gulf of Policastro, south of Naples, a submarine fresh water spring emerges from the sea bottom in 10 fathoms, and on account of its density difference it rises to the surface. Here in agitated weather conditions, a zone of calm water is created in the lee of the emergent fresh water.

The most striking example of natural wave stoppage, by a discontinuity has been recorded by J. D. Isaacs.[2] The facts are worth quoting in extenso because they well illustrate, in the view of the present writer, the principle underlying the modus operandi of the pneumatic breakwater, albeit without the bubbles.

"Another marked effect of currents on waves is the moderating effect of discontinuities in open water . . . . The writer first observed it off the Oregon Coast in August 1939. A strong wind of 25-30 knots had blown for 14 hours from the northwest. Waves of 10-12 feet in height and about 6 second period (L=180 feet) predominated. A course of 90 degrees was held towards the shore. At sunset an extremely choppy and confused region was encountered and shortly after the sea moderated greatly. A swell of about 4 feet high and 12-15 second period (length 730-1140 feet) characterised the sea surface in this region. On returning next morning to the zone of discontinuity, a line of flotsam was encountered, and almost immediately, to the seaward of the flotsam, a confused and choppy sea. The water to seaward was apparently flowing southward relative to the other water at an estimated 2 knots, and eddies were apparent where masses of floating seaweed rotated.

"To the seaward of this junction the sea was extremely rough and choppy and tossing waves were apparent similar to those encountered off precipitous headlands. Very smooth water existed to shoreward. A fix was obtained and no bottom found at 100 fathoms . . . ."

There are several points of great interest in this account. The discontinuity here described was apparently effective in reflecting the short 180-ft. steep "sea," completely. The long swell which remained on the lee side must have been of different origin, since it is impossible for a reflecting (or refracting) system to change the wave frequency. It may be asked why did not the discontinuity reflect the swell as well as the short "sea"; the answer no doubt is that the discontinuity need only have extended downwards for 90 feet to intercept 96 per cent. of the motion of the short waves, while it would have to have extended to between 365 and 570 feet to perform the same office for the long swell. Here in fact we have an interesting example of a breakwater of finite depth completely intercepting a wave of short length while letting through a substantial fraction of the energy of a long wave. The complete abolition of a 10-12 foot sea by a discontinuity of no more than 3.4 feet/second is impressive, and is by no means irrelevant to the possibilities of effective protection by a short pneumatic breakwater. The short steep seas on the seaward side plainly have a large component of standing waves.

Summing up this section, we must regard the pneumatic breakwater, not, as in the past, as a device for creating surface currents which will cause waves to break, or prevent their further advance by the generation of opposing forces, but as a means of creating at will, and in chosen locations, a discontinuity in the vertical plane beyond which the waves will not pass. Enough has been said, we think, to indicate that the efficacy of a pneumatic breakwater largely depends on the depth to which the discontinuity can be carried. The method by which the water can be energised not only near the surface but also near the bottom is a matter of technique, and forms no part of the present discussion. Suffice it however to state, that in the writer's view neither the models which have been tested nor the full scale pneumatic breakwaters which have as yet been constructed have more than scratched the surface of a problem whose solution is within reach. The writer would go further and would say that the omens are against effective investigation by means of models, and that from his own experience he is in entire accord with the German authors when they say that there is no apparent relation between the energy required in models and that which has been found effective, or fairly effective at full scale. This brings us to the question of the validity of scale models for this particular work.

The Question of Dynamical Similarity.

The authors state in their opening remarks that Froude's Law of Similarity may be taken to hold good for wave investigations in a model tank, while at the same time agreeing with previous experimenters that when it comes to projecting the model results to full scale, the volumes of air required at full scale is 500 to 750 times *less* than the model would predict. Now it is well enough to assume that gravity waves by themselves in a model conform to Froude's Law. But when we come to consider what is happening in the tank when the pneumatic breakwater is at work, the argument no longer applies. Among the phenomena which we have discussed there are in particular those of induced currents, orbital velocities and discontinuity. That is to say that there are shear stresses between the water-air column and still water, and between the moving water and the oscillating particles. It follows therefore that among the influences at work both in models and at full scale due account must be taken of viscosity, friction and turbulence. Admitting these elements into the picture involves the necessity of obtaining an expression for corresponding speeds for viscosity. Without going into overmuch detail it may be said that in a model which is for example to 1/12 scale, dynamical similarity can be secured only if the velocities of all the components of the experiment *in which viscosity plays a part* are *twelve times* greater than in the full scale prototype. In the model those motions which are produced by the wave itself and by the velocity of ascent of the bubbles have a velocity which is $\sqrt{12}$ that of the prototype. There is thus a velocity discrepancy in models which is $12\times\sqrt{12}=41.5$ times too low. Herein we think is part of the discrepancy between model and prototype which has mystified more than one experimenter.

Conclusion.

The model investigations of the pneumatic breakwater which have been conducted at the Franzius Institute form a valuable addition to the knowledge of this subject. The authors are to be congratulated on planning, completing and publishing their work in less than nine months.

The unpopularity of the pneumatic breakwater as an economical supplement to conventional harbour works is shown to have arisen partly from the verdict of Schijf that unacceptable volumes of air would be required. Another deterrent has been the irreconcilability of model experiments with the results, as yet few, which have been obtained at full scale.

The present writer has tried to show wherein the discrepancy between model and full-scale lies. The train of argument has indicated that the Franzius Institute theory of operation will not satisfy the physical facts. An alternative theory has been brought forward, which is not inconsistent with the facts, and which also serves to link the action of the pneumatic breakwater with accidental wave reductions occurring in nature. This device appears to be just another imitation on a modest scale of something that nature has been doing for millions of years.

The above theory of operation indicates the importance of taking account of viscosity. Consequentially, the current assumption that Froude's Law is the only criterion as between model and prototype becomes incorrect, and part at least of the discrepancy is at once accounted for. The remainder of the discrepancy probably will be found not unconnected with the increased effective work done by compressed air in deep water.

Here in the writer's view is an instrument of great utility, for the improvement of existing harbour works, for the creation of sheltered water where none at present exists or where conventional workers are ruled out for one reason or another, for improvement of offshore loading conditions, and for the protection of landing beaches in amphibious warfare.

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[2] Isaacs, J. D.: "Trans. Amer. Geophys. Union," Vol. 29, No. 5, 1948.

Pneumatic Unloading Plant at Kitimat

Discharging Alumina at New Wharf

(Specially Contributed)

Although the power and smelting facilities of Aluminum Company of Canada Ltd. represented an important and growing enterprise in Eastern Canada, it became evident before 1950 that the western nations required increased quantities of aluminium for civilian use.

The process developed in 1886, which has transformed aluminium from a rare metal into the leading non-ferrous metal in volume consumption, requires large supplies of electricity to separate the metal from its ore. The low-cost production of aluminium, unlike that of most commercial metals, therefore depends almost entirely on the existence of favourable water facilities for hydro-electric power generation.

Aluminum Company of Canada consequently decided to build a power house, smelter and port on the mountainous Pacific coast of British Columbia, where a large block of hydraulic power could be developed. A dam has been placed across the Nechako river, reversing the flow from east to west; the water forms a 125-mile reservoir ending in Tahtsa Lake. From this lake a ten-mile water tunnel has been cut through the mountains to Kemano Power House, and from there transmission lines carry power to the Kitimat aluminium smelter 50 miles away.

Alumina, one of the major raw materials for the Kitimat smelter, is supplied by Alumina Jamaica Limited. The alumina is unloaded at the new dockside at Kitimat by travelling pneumatic plant which has been designed and built by Simon Handling Engineers Ltd. The plant, which is 95-ft. high and weighs 300 tons, is electrically operated and is designed to deliver alumina from ships' holds in a continuous stream to an overhead gallery conveyor at a rate of 180 tons an hour.

There are three suction pipe booms, each having an outreach sufficient to command both the largest and the smallest vessels likely to be unloaded at Kitimat. The luffing and telescoping motions are provided by electric winches, which are actuated from remote-control push-button stations suspended into the ships' holds so that the booms can be controlled by the nozzle attendant; the boom motions can also be controlled from a central control room on the second floor of the traveller.

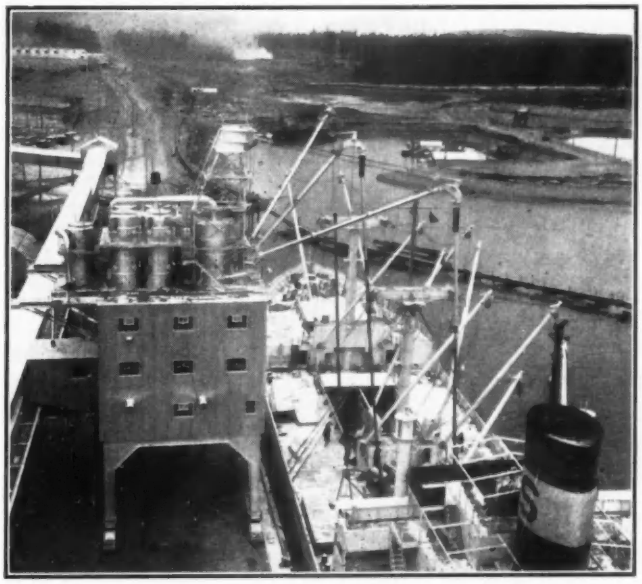
To ensure the complete withdrawal of all alumina from the corners of the holds, each of the main suction pipes can have attached to it a breeches pipe, to which are connected smaller diameter flexible pipes with cleaning-up nozzles.

Each nozzle is connected with quick-coupling flanges to a series of flexible pipes of the armadillo type which can be easily moved in the ship's holds. In ascending order, each pipe boom then consists of portable steel pipes, a telescopic pipe, and a second flexible pipe. The latter connects to a ball joint which gives added flexibility of movement to the suspended pipes, the ball joint finally connecting to a pipe boom bend of special heavy construction and with renewable wearing plates in two sections.

The pipe booms are connected to an alumina receiver through special swivel joints with renewable wearing plates. The swivel joints give the booms a wide range of movement: they can operate in any position from 10° to 55° above the horizontal, and when not in use they can be stowed in any position from 10° below to 70° above the horizontal; the two outer booms can be slewed through 180° to a position in which they can easily be inspected and over-hauled. The connecting pipes between the swivel joints and the receiving vessel have isolating valves, so that one or more of the booms may be put out of the circuit if necessary.

Before dealing with the machinery in detail, the general layout may be referred to. It is perhaps scarcely necessary to point out that the operation of the plant may be likened to that of the domestic vacuum cleaner, the alumina being sucked from the hold and deposited in a receiver. The analogy, however, can be pursued no further, the alumina being automatically discharged as it is picked up, and not collected as is the dust in a vacuum cleaner. The operation of alumina-discharging therefore necessitates the creation of a vacuum by large pumps.

Two sets of vacuum pumps are provided to deal with the full capacity and at the same time provide a standby for working at a lower capacity during maintenance work on one set, and also to ensure a well balanced design of structure. These pumps are of special Simon design for this class of work, having valves easily accessible for inspection or renewal and pistons with rings having dry lubrication. Each pair of pumps is of the double-acting reciprocating type, with ring-oiling bearings for the main crankshafts and



Pneumatic Unloader at work at Kitimat, British Columbia.

mechanical lubrication to the reciprocating parts. The cylinders are carried on "A" frames supported on heavy cast iron bedplates, and the crankshaft is extended to carry flywheels suitably balanced and having a raised portion to carry the Renold chain drive in the centre. The cylinder covers have quick-operating inspection doors, so that the valve units, which are complete in themselves, can be inspected conveniently. The vacuum pumps are size 14A running at 142 r.p.m. and are chain driven from motors of 200 B.H.P. each.

The power wiring and electrical equipment is designed and approved by the Canadian Standards Association, having collector gear of the four-shoe type, supported from the structure by two insulators, pivoted and sprung to allow for irregularities in the conductors during travel along the quay. The main motor control centre contains the incoming supply circuit-breakers fed from the collector gear, and all control units for filters, winches, dust plants, alumina plant and traversing gear.

All motors, brakes, and traversing motor controllers are in accordance with local regulations and are specially designed for their separate duties. Limit switches are fitted throughout wherever movement of structure or pipe booms is concerned. Winch ropes are fitted with slack rope gear and contacts to ensure that all movements are under automatic control. A very complete alarm system is fitted.

The alumina drawn up through the suction intake pipes is discharged into the receiver, in which the expansion and loss of velocity of the conveying air-stream allow the alumina to drop out of suspension and collect in the discharge hopper of the receiver: this hopper is of the divided type with two outlet points, through which

Pneumatic Unloading Plant at Kitimat—continued

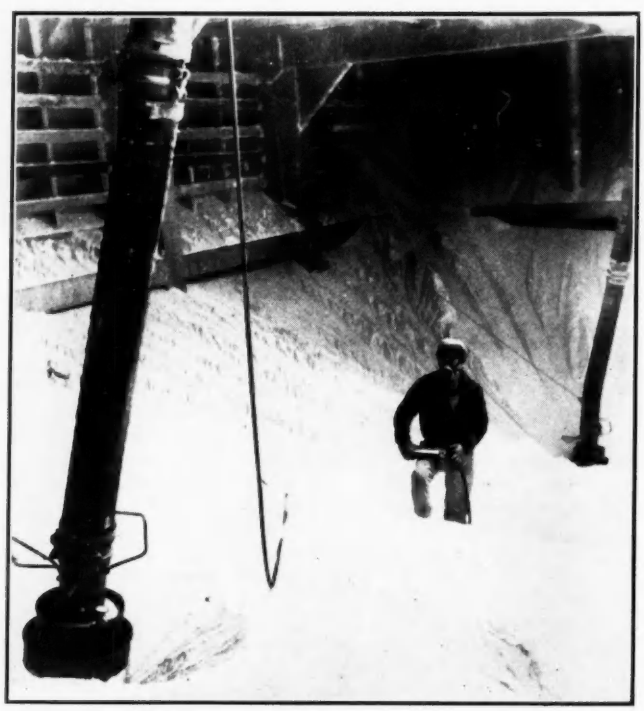
the alumina is delivered into a large compensating hopper. The alumina is released from the receiver without breaking the vacuum by means of standard-type Simon tipper seals, one of which is fitted to each outlet. The tipper seal consists of two compartments, each of which is alternately brought under the alumina outlet by mechanically oscillating the tipper from side to side on a shaft: while one compartment is under the outlet and is receiving alumina under vacuum (its swinging discharge door being meanwhile held shut by atmospheric pressure) the other compartment is open to atmosphere, thus releasing the vacuum and allowing its discharge door to open and release the contents into the compensating hopper below.

When the alumina enters the receiver the finer particles and dust do not settle at once but remain suspended in the air: special means are necessary to collect these fine particles, partly on account of their value and partly to prevent them entering the vacuum pump cylinders and causing wear. A primary dust-collecting cyclone is therefore fitted inside the receiver: this cyclone collects the bulk of the fine suspended particles and discharges them into the compensating hopper through a third tipper seal similar to, but smaller than, those under the two main receiver outlets.

After the alumina has been discharged by the tipper seals into the compensating hopper, it passes through adjustable outlet valves into two " Airslide "-type conveyors which transport it 50-ft. across the plant and deliver it in a continuous stream on to an overhead gallery conveyor. The compensating hopper, which has renewable wearing plates, has two high level bin indicators which would indicate a blockage in the conveyors. These have three inlet points, one for the main hopper feed and two for auxiliary dust feed from filter stations. A centrifugal fan has been supplied with each one to provide the necessary conveying medium.

Any material or light flying dust which escapes the influence of the internal cyclone is carried by the air stream into a comprehensive system of automatic shaking textile sleeve filters mounted on the upper deck of the structure adjacent to the receiver.

The filter installation consists of four identical units, each with an inlet section, a fabric filter section and a gate lock to discharge the collected material to atmosphere against the vacuum. The inlet hopper consists of a cylindrical section with a conical hopper beneath. The high velocity inlet is situated tangentially at the lower end of the cylindrical section, the dust-laden air stream impinging on detachable wearing plates. A special helical baffle guides the inlet air stream, centrifugal action removing some of the dust content.



Unloading Alumina from a ship's hold. In the foreground is the suction nozzle; the operator is seen controlling from a remote control panel resting on his knee.

Part of the control room. This room is pressurised as a protection against the inflammable nature of coke dust.

The cylindrical filters are mounted over the inlet sections and each filter is divided into two segmental sections, each section having upper and lower circular access doors. In each sector the sleeves are suspended by quick-acting fittings from a frame mounted on the lower end of a vertical shaft which passes through a bushed housing in the top plate. The shafts are reciprocated by individual eccentric mechanisms and the high-frequency vibrations thus imparted to the sleeves clean the fabric. Each sector exhausts through a pneumatically operated valve, closure of the valve automatically initiating shaking of the sleeves. The air inlet valve is arranged to admit a metered quantity of atmospheric air through the fabric to assist in cleaning.

A pneumatic controller operates each of the valves in sequence, the interval between successive operations being mechanically adjustable. A standard type of air compressor and receiver are included for the necessary air supply. The material dislodged from the sleeves settles into a hopper and is removed by a pneumatically-driven gate lock equipped with three gates. The gates function in automatic sequence and the chambers are automatically ventilated. The dust then passes by chutes into the two " Airslide "-type conveyors to join the main stream of alumina.

Dust from the delivery ends of these two conveyors and the loading shoes feeding the overhead gallery conveyor is collected by a further automatic shaking filter on the upper deck. This filter also exhausts the tipper discharge room (which is totally enclosed) thus keeping the dust nuisance at a minimum. The plant is almost identical to the main filter station, the main difference being that conveying air is provided by a fan on the second floor, the cleaned air being exhausted to atmosphere. The dust collected is discharged at intervals through a balanced valve by chutes into the " Airslide "-type conveyors.

Pneumatic Unloading Plant at Kitimat

From the main filters, the cleaned air is drawn into a large air expansion vessel fitted with a fine mesh grid for final protection of the double-acting reciprocating vacuum pumps. Four dust detectors are fitted inside the vessel; the plant operator can close any filter which is letting through an excessive amount of dust and thus prevents serious damage to the vacuum pumps. The air then passes into the vacuum pumps to be finally exhausted to atmosphere.

Discharging Coke.

Beneath the two compensating hopper outlets in the chute system feeding the " Airslide "-type conveyors are two diverting valves which are used to by-pass them when coke is unloaded from small coastal vessels. The coke is delivered to the overhead gallery conveyor on a band conveyor.

Control Room.

The central control room, from which one man can control the plant, is deemed to be a " hazardous location " and is therefore pressurised. This is a protection against the inflammable nature of coke dust, but at the same time prevents the entry of alumina dust and the consequent fouling of the control gear.

Travelling.

The complete equipment is mounted on a travelling structure having four pairs of pivoting-type, three-wheeled bogies, two pairs of which are directly driven through worm-reducing gear boxes, then by straight spur gear. The travelling gear propels the structure in either direction along the tracks at a speed of approximately 30-ft. per minute. There are two 20 h.p. synchronous motors for driving the structure.

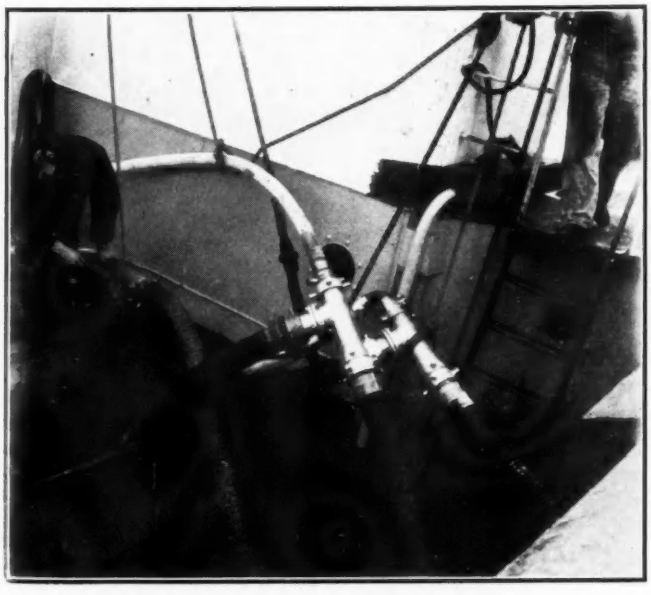
Southampton Salvage Incident

In our November, 1954, issue, we published a description of the Ejector Pump developed by the Southampton Fire Brigade for use on ship fires. Evidence of the usefulness of this pump was demonstrated last April, when it was successfully employed to prevent the sinking of a damaged ship.

The Southampton Fire Brigade received a call for assistance to the S.S. " Sandiver," a vessel of 380 tons gross which was in imminent danger of sinking as she had fouled the stump of a pile, causing damage to the plating below the water line amidships, flooding the cargo hold, storeroom and pump room.

A Pump and Fire Boat were despatched and three Ejector Pumps were quickly placed in position, the Fire Boat being used to supply the delivery lines to the priming nozzles. There was a small mechanical salvage pump already in operation in the hold when the Brigade arrived but, due to exhaust gases, it was necessary to stop this pump.

It was estimated that the discharge from the Ejector Pumps was approximately 1,200 gallons per minute and as they were able to cope with the inflow of water, it was decided that, provided pumping operations continued, the vessel could be moved on to a slipway. Three hours later, the vessel, accompanied by the Fire Boat, which maintained the feed to the Ejector Pumps, left the berth and was placed in a cradle on a slipway.



Ejector Pumps working on S.S. " Sandiver."

Manufacturers' Announcements

New Lantern for Dock Lighting

A new lantern for lighting docks, quays and ships alongside, was recently introduced by The General Electric Co. Ltd. Accommodating two 400W horizontal-burning mercury lamps, the lantern provides the high level of illumination required for undertaking detailed repairs.

The lantern consists of an anodised aluminium reflector rigidly fixed between two silicon aluminium end castings which are held together by a central tie rod and two extruded aluminium members. In each end casting is a hinged door, with weatherproof gasket, which provides access for servicing. The front is of toughened rough-cast diffusing glass sealed in a substantial cast aluminium frame and securely fixed with a weatherproof joint which normally need never be broken. The lantern is dust-proof and weatherproof. Gear must be mounted separately.

The galvanised steel mounting bracket provides adjustment for varying the beam axis between 20° and 50° below the horizontal. Light close to the horizontal is limited by a glare shield in the lantern. The standard mounting provides for attachment to a 3-in. dia. vertical pole but other sizes of clamps can be supplied to meet users' requirements.

New Bridge for Iraq

A contract to the value of £450.000 has been awarded to Sir William Arrol & Co. Ltd., Glasgow, for the complete construction of embankment approach roads, piled abutments and river piers and the steel superstructure of a new highway bridge over the River Euphrates at Samawa, about 175 miles south of Baghdad.

The overall length spanning the river of 527-ft. comprises a central span of 261-ft. between the river piers which carry the main towers, and two side spans each of 133-ft. from pier to abutment.

The bridge, which is a suspension bridge of the self-anchoring type, provides a carriage-way 26-ft. 3-in. wide between the main stiffening girders and two foot-ways each 6-ft. 6-in. wide cantilevered on the outside of the girders. The main stiffening girders are of box construction and each main cable is composed of 270 high tensile wires of 0.276-in. diameter. The entire superstructure, totalling approximately 800 tons, including structural steelwork, cables and suspenders, will be of high tensile steel.

The work is to be executed to the order of the Iraq Development Board, and the Consulting Engineers are Messrs. Maunsell, Posford & Pavry of Westminster, S.W.1.

Manufacturers' Announcements—continued

Universal Pile Driver

Early last month a demonstration was given of a new 100-ft. Pile Driver, which had been specially built to the order of Christiana & Nielsen Ltd., London, for the Hampshire County Council Langstone Bridge Contract.

The Contract includes the reconstruction of over 3,500-ft. of roadway which connects Hayling Island, lying between Chichester Harbour and Portsmouth, to the Mainland. Of this about 1,600-ft. will be constructed on new embankments, 956-ft. is to bridge over the Channel, and the rest represents a re-routing of the present road. The channel is to be bridged in 29 spans of 32-ft., with a number of smaller spans at expansion joints. It is anticipated that some of the piles will be 80-ft. long and will weigh over 9 tons and to drive them, a hammer with a falling ram of 6 tons has been thought necessary. The concrete piles will be driven from a temporary timber staging driven in advance of the main pile driving by a smaller cantilever pile frame.

Such a major task as this called for a pile driver 100-ft. high, of very sound construction, with the ability to slew, rake and travel along an undercarriage, and with such a big frame it was considered a wise investment to have all of these operations carried out under the pile frame's own power.

The equipment was designed and manufactured by Woodfield Hoist and Associated Industries Ltd., Rochester, and was sold by the Sole Agents for Great Britain, Vales Plant Register Ltd., 14, Lower Grosvenor Place, London.

Frame in forward raking position.

In order to minimise the amount of auxiliary timber staging required while working over the sea, the machine can be operated from the winch platform and is able to carry out every manoeuvre under its own power. In addition to operating the hammer, these comprise slewing through a full circle, backward and forward raking, and travelling on a rail track as well as assembly and dismantling.

The winch frame is bolted to the upper base of the structure and is easily removable. The winch, mounted on a skid base, is built in two halves; the cylinders and rear drum are integral and can be removed from the winch base to be used as a single drum winch. For the two remaining drums a sub-frame can be supplied so that a suitable diesel or petrol engine can be bolted to the skid base, providing two winches.

The undercarriage runs on a track measuring 14-ft. 6-in. between rail centres. Its four wheels are driven from the winch through bevel gears, and on it the platform turns on twelve spider-mounted rollers, which are arranged inside the circular slewing track. On the platform are mounted the winch and two steam boilers, one for operating the winch and the other for the hammer. The 65-ft. high superstructure is carried on two pivots at the front end, and is supported on each side by a bevel-driven raking screw.

The drive to all motions other than piling or pile pitching is taken from the front drum shaft, through a claw clutch to a chain sprocket and thence to the main transmission shaft, on which are mounted three claw clutches driving through bevel gears for slewing and travelling, and straight tooth gears for raking, although the final drive to the raking screws is by bevel gear.

The 100-ft. leader is hinged to the crown block by retractable pins. Its lower end slides in a block hinged to a horizontal extending strut at platform level, so that by raking the superstructure and adjusting the strut the leader can be set at the angle required. By engaging the crown block pins at different positions, the leader may be lowered to 24-ft. below the track.

At the demonstration the 7 ton hammer was raised to the top of the leader and lowered. Backward raking was also demonstrated. The superstructure was raked back until the leaders had a rake of 1 : 2½. Whilst piling at this angle rear jacks are required, but for all other duties, except dismantling, jacks are not necessary. The rate of slewing is 2 r.p.m. In travelling, the winch operates with little vibration; this is due among other things to the low positioning of the crank-shaft. The speed of travel is 3-4 m.p.h.

Further operations shown were forward raking, lowering the leaders, and lowering and re-erecting the superstructure. The leaders are adjustable downward for a distance of 24-ft. in four steps of 6-ft. Their lowering is effected by the pile pitching ropes and no extra reeving is required. Any make of hammer complying with British Standards can be used with these leaders, single acting, double acting, fully automatic or drop hammer.

Both the frame and the leaders can be reduced in height by removing sections from each, thus reducing them to 52-ft. and 85-ft. respectively.

Packing to Counteract Pilferage

In the recently published Annual Report of the Liverpool Underwriters Association, deep concern is expressed at the extensive theft and pilferage in ports throughout the world. Indeed, of the 30-odd pages of the Report, nearly two complete pages are devoted to this topic.

Part of the blame for the sort of conditions conducive to theft and pilferage are attributed to the exporters themselves: "The attention of the committee has frequently been called to the poor quality of packing still prevalent, in spite of the improvement in the availability of the necessary materials. It has been stated that, even under conditions of normal handling, goods in some instances are so poorly packed that they would stand little or no chance of arriving in sound condition."

Different methods of packing to counteract theft and pilferage have been the subject of an investigation made recently by Venesta Limited, Vintry House, Queen Street Place, London, manufacturers of plywood cases. Amongst important conclusions drawn from this survey is the fact that greater all-round protection is given to export goods by using specially designed plywood cases as against softwood or other types of packing materials. As a result, Venesta have concentrated on the production of a special plywood export case which not only embodies several new features for counteracting theft and pilferage, but also achieves a substantial saving in both insurance and freight costs. This packing case is known as the "Pattern 201" and is claimed to have achieved considerable success.

British Radio for Fishing Fleet

A fleet of 75-ft. motor trawlers built in Hongkong for the South Korean Government under a United Nations Korean Reconstruction Agency procurement plan and now operating from Pusan have been equipped with Redifon radio equipment supplied by Redifon Ltd., London. The equipment consists of Redifon G.47 BM transmitters and R.55 receivers. Redifon radio equipment is now well known among trawler fleets, and among recent orders received by the company was one to equip 20 fishing vessels for the Soviet Union.